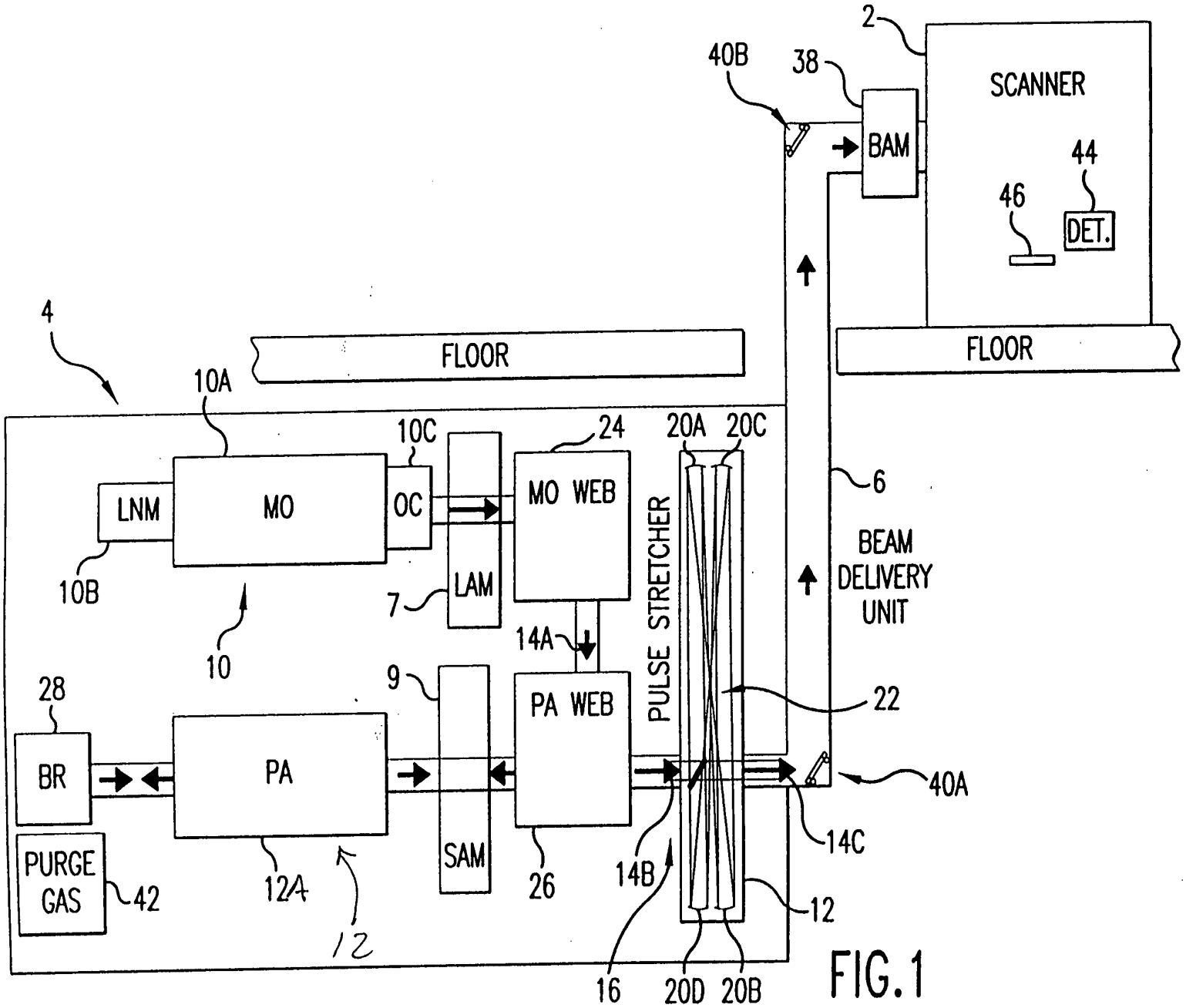

2
SCANNER
40B
38
BAM
44
46
DET.
FLOOR
FLOOR
4
10A
10C
24
20A
20C
LNM
MO
OC
MO WEB
6
BEAM
DELIVERY
UNIT
10B
10
7
LAM
14A
PULSE STRETCHER
9
28
22
PA WEB
BR
PA
40A
PURGE
GAS
42
12A
SAM
26
14B
14C
12
12
16
20D
20B

FIG.1

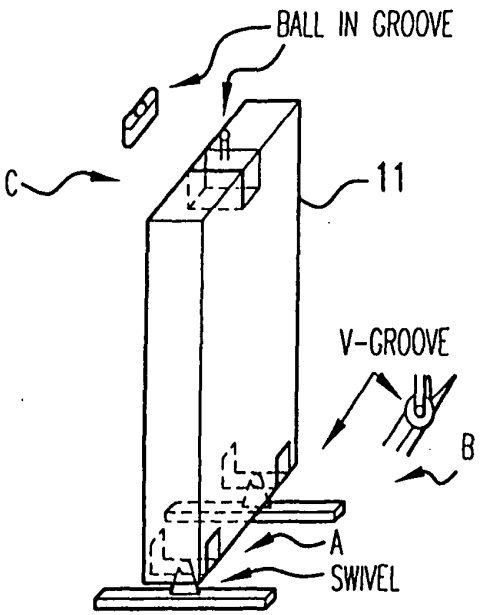

BALL IN GROOVE
C
11
V-GROOVE
B
A
SWIVEL

FIG.1B

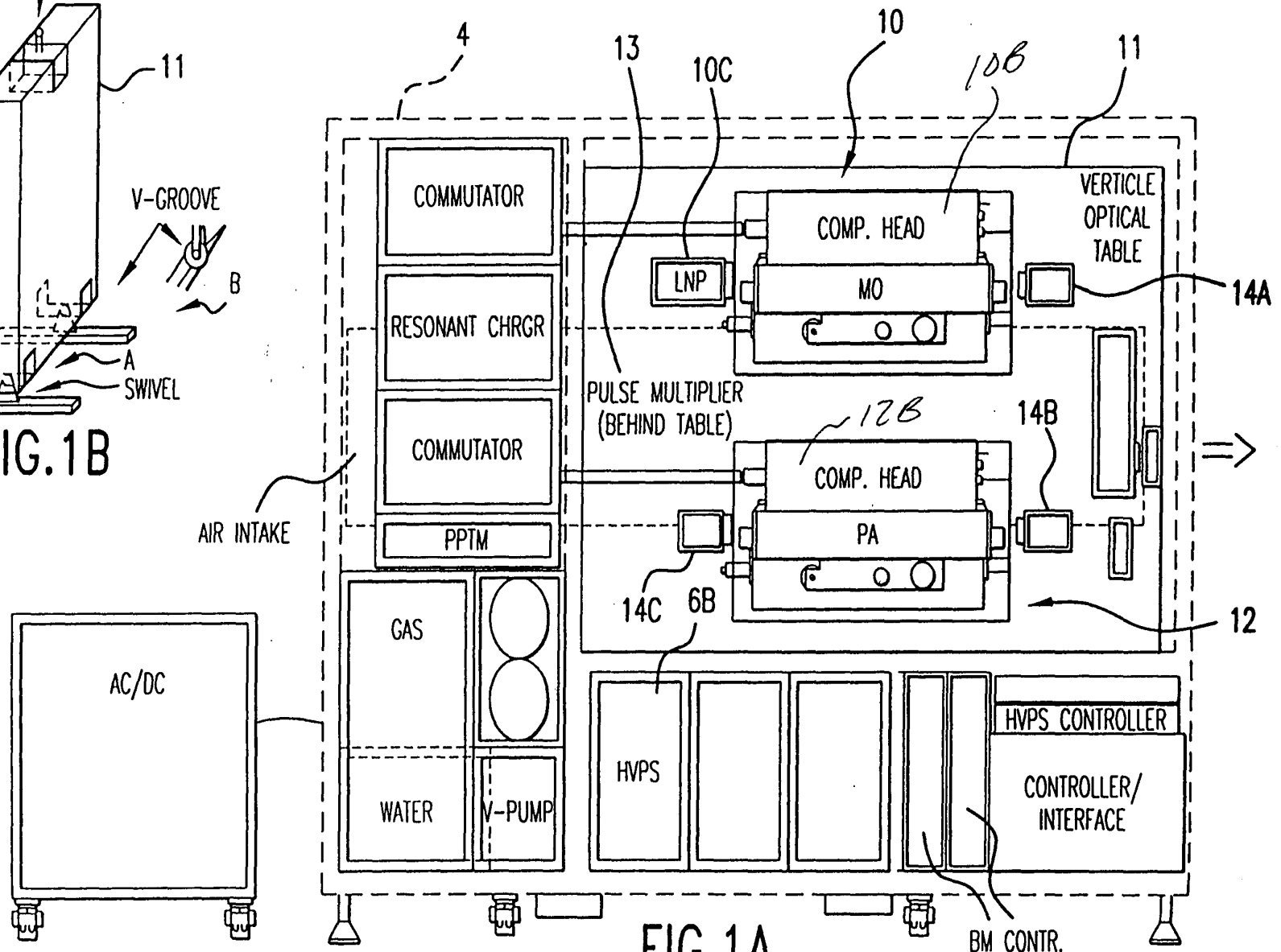

4
13
10C
10
10B
11
VERTICLE OPTICAL TABLE
COMMUTATOR
RESONANT CHRGR
COMMUTATOR
PPTM
LNP
COMP. HEAD
MO
14A
PULSE MULTIPLIER (BEHIND TABLE)
12B
14B
COMP. HEAD
PA
AIR INTAKE
14C
6B
12
AC/DC
GAS
WATER
V-PUMP
HVPS
HVPS CONTROLLER
CONTROLLER/ INTERFACE
BM CONTR.

FIG.1A

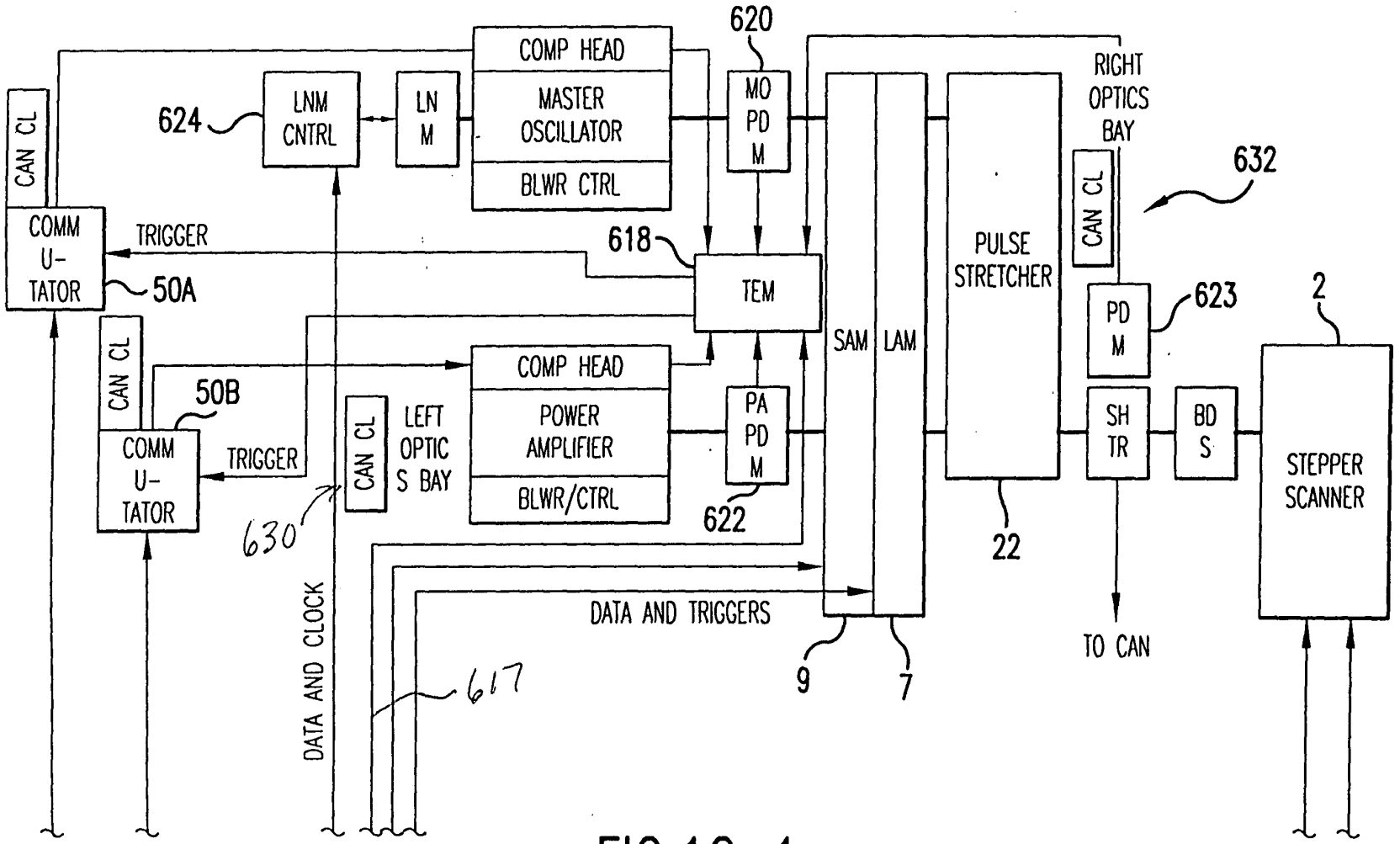

620
COMP HEAD
MASTER OSCILLATOR
BLWR CTRL
624
LNM CNTRL
LN M
MO PD M
RIGHT OPTICS BAY
CAN CL
632
COMM U-TATOR
50A
TRIGGER
618
TEM
PULSE STRETCHER
CAN CL
PD M
623
2
CAN CL
50B
COMP HEAD
POWER AMPLIFIER
BLWR/CTRL
PA PD M
622
SAM
LAM
SH TR
BD S
STEPPER SCANNER
COMM U-TATOR
TRIGGER
CAN CL
LEFT OPTIC S BAY
630
22
DATA AND TRIGGERS
TO CAN
DATA AND CLOCK
617
9
7

FIG.1C-1

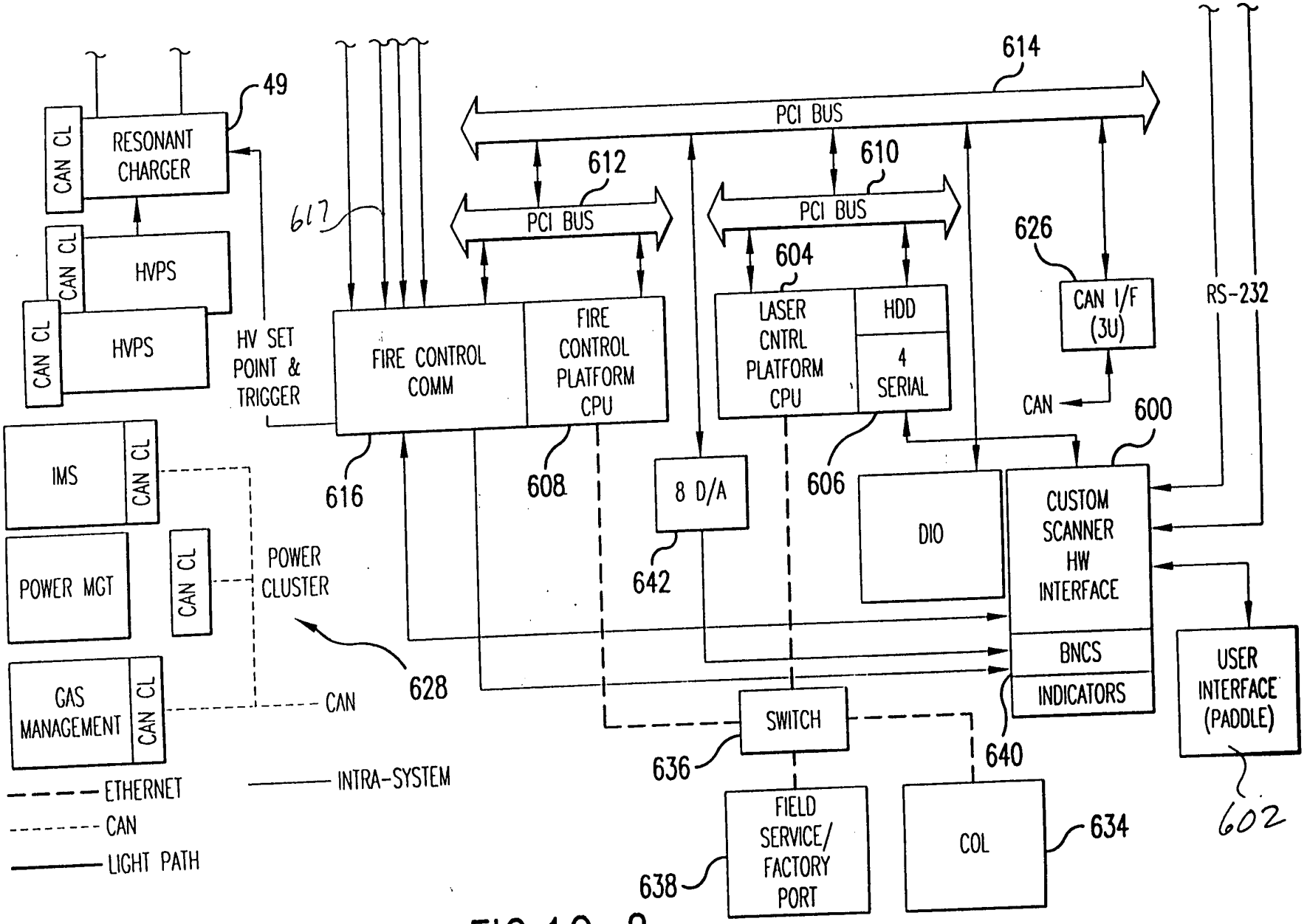

49
RESONANT CHARGER
CAN CL
HVPS
HVPS
HV SET POINT & TRIGGER
617
614
PCI BUS
612
PCI BUS
610
PCI BUS
604
FIRE CONTROL COMM
FIRE CONTROL PLATFORM CPU
LASER CNTRL PLATFORM CPU
HDD
4 SERIAL
626
CAN I/F (3U)
RS-232
CAN
600
IMS
POWER MGT
GAS MANAGEMENT
POWER CLUSTER
628
616
608
8 D/A
642
606
DIO
CUSTOM SCANNER HW INTERFACE
BNCS
INDICATORS
USER INTERFACE (PADDLE)
602
SWITCH
636
640
FIELD SERVICE/ FACTORY PORT
638
COL
634
ETHERNET
CAN
LIGHT PATH
INTRA-SYSTEM

FIG.1C-2

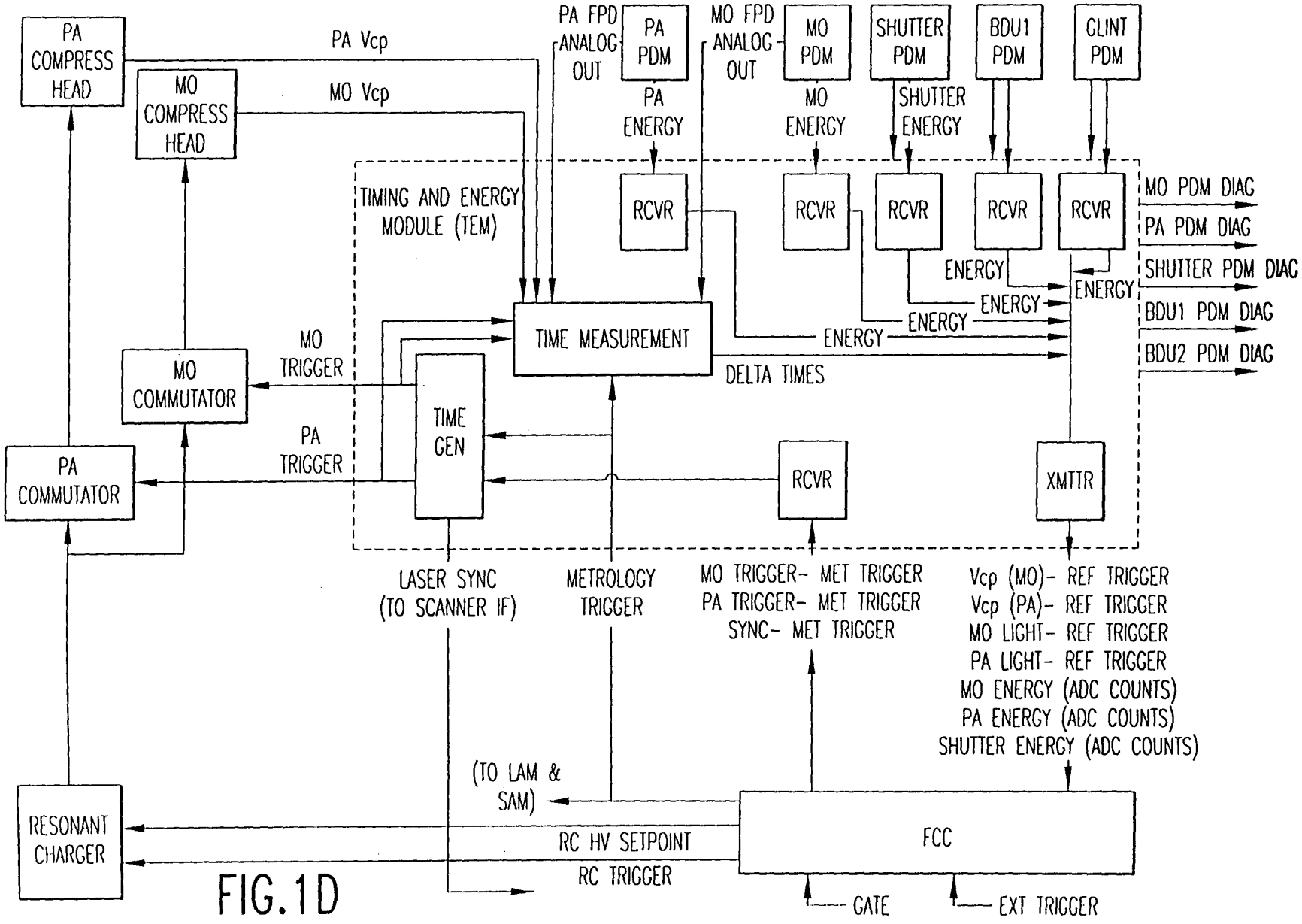

PA COMPRESS HEAD
MO COMPRESS HEAD
PA Vcp
MO Vcp
PA FPD ANALOG OUT
PA PDM
MO FPD ANALOG OUT
MO PDM
SHUTTER PDM
BDU1 PDM
GLINT PDM
PA ENERGY
MO ENERGY
SHUTTER ENERGY
TIMING AND ENERGY MODULE (TEM)
RCVR
RCVR
RCVR
RCVR
RCVR
MO PDM DIAG
PA PDM DIAG
SHUTTER PDM DIAG
BDU1 PDM DIAG
BDU2 PDM DIAG
ENERGY
ENERGY
ENERGY
ENERGY
ENERGY
TIME MEASUREMENT
DELTA TIMES
MO TRIGGER
MO COMMUTATOR
PA TRIGGER
PA COMMUTATOR
TIME GEN
RCVR
XMTTR
LASER SYNC (TO SCANNER IF)
METROLOGY TRIGGER
MO TRIGGER- MET TRIGGER
PA TRIGGER- MET TRIGGER
SYNC- MET TRIGGER
Vcp (MO)- REF TRIGGER
Vcp (PA)- REF TRIGGER
MO LIGHT- REF TRIGGER
PA LIGHT- REF TRIGGER
MO ENERGY (ADC COUNTS)
PA ENERGY (ADC COUNTS)
SHUTTER ENERGY (ADC COUNTS)
(TO LAM & SAM)
RESONANT CHARGER
RC HV SETPOINT
RC TRIGGER
FCC
GATE
EXT TRIGGER

FIG.1D

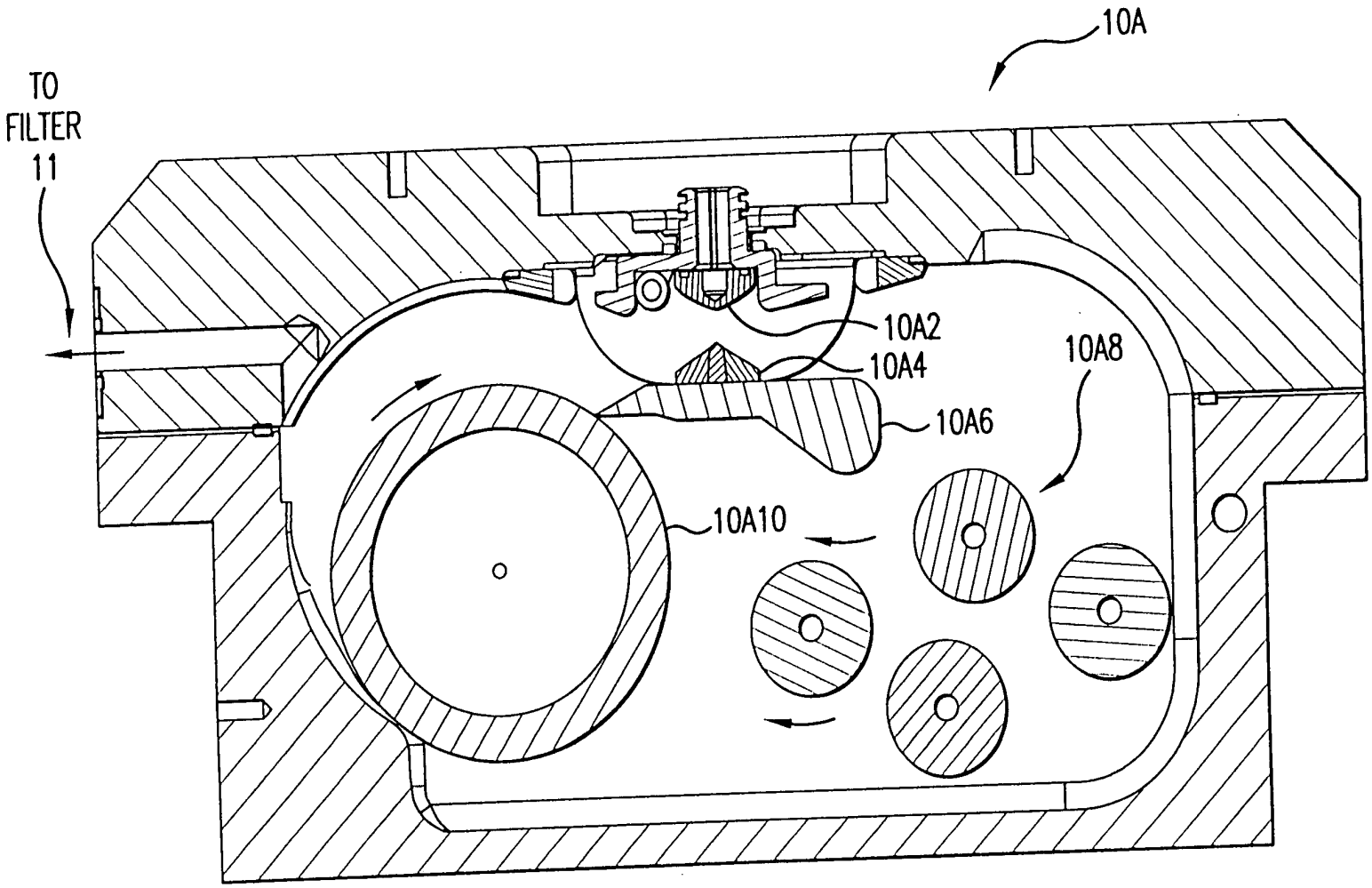


FIG. 2

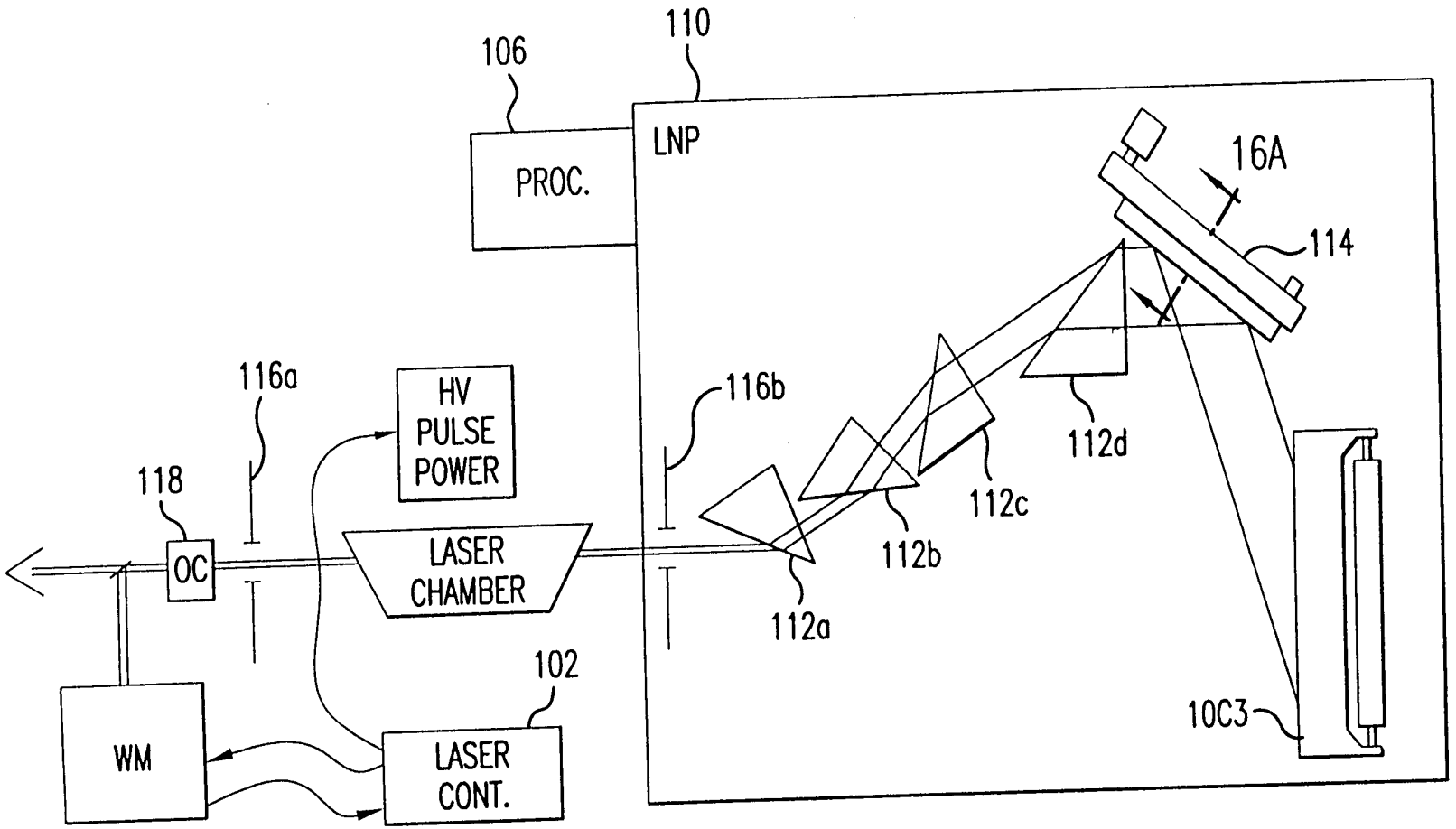

106
110
PROC.
LNP
16A
114
116a
HV
PULSE
POWER
116b
118
112d
112c
OC
LASER
CHAMBER
112b
112a
102
10C3
WM
LASER
CONT.

FIG.3

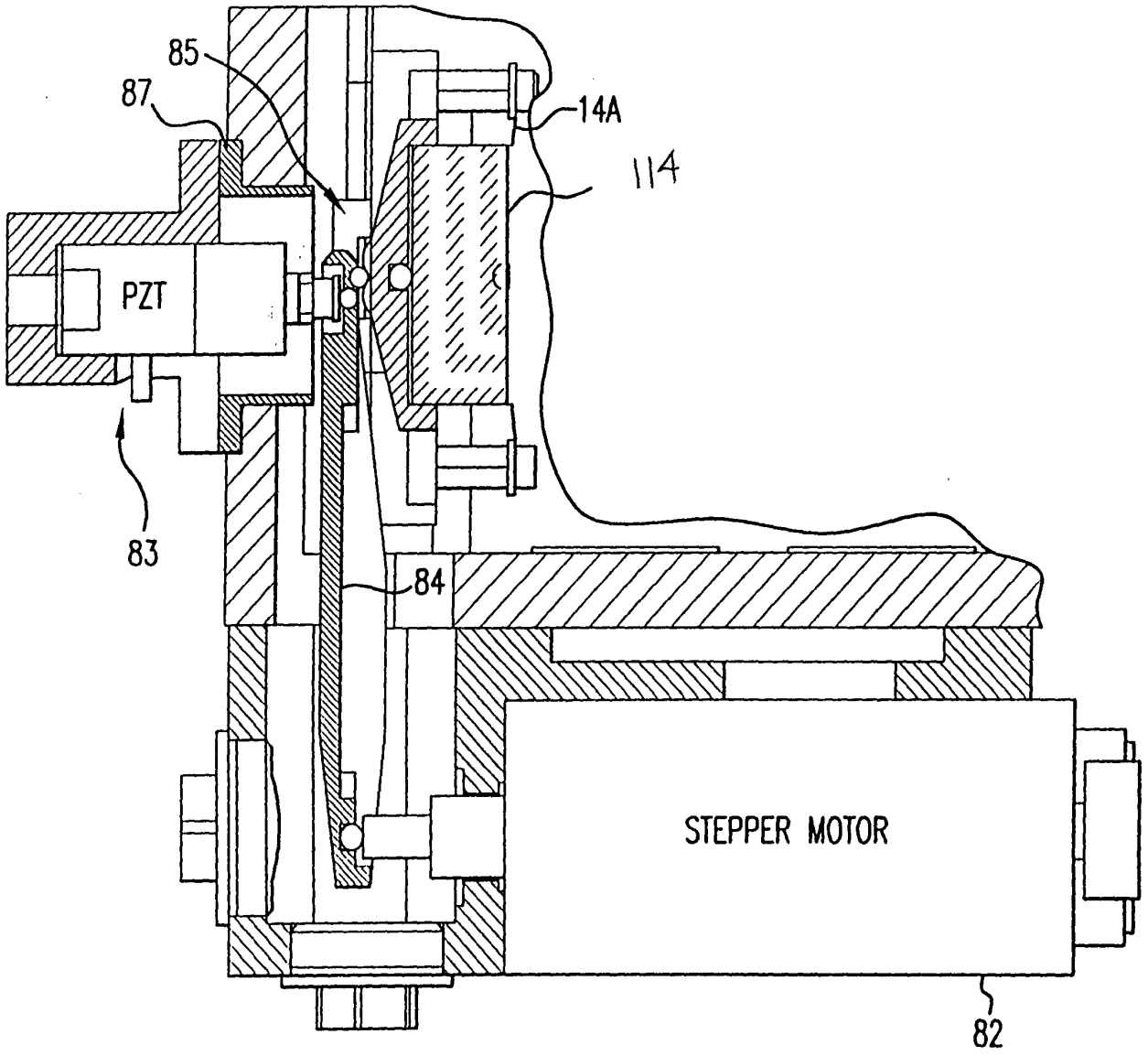


FIG.3A

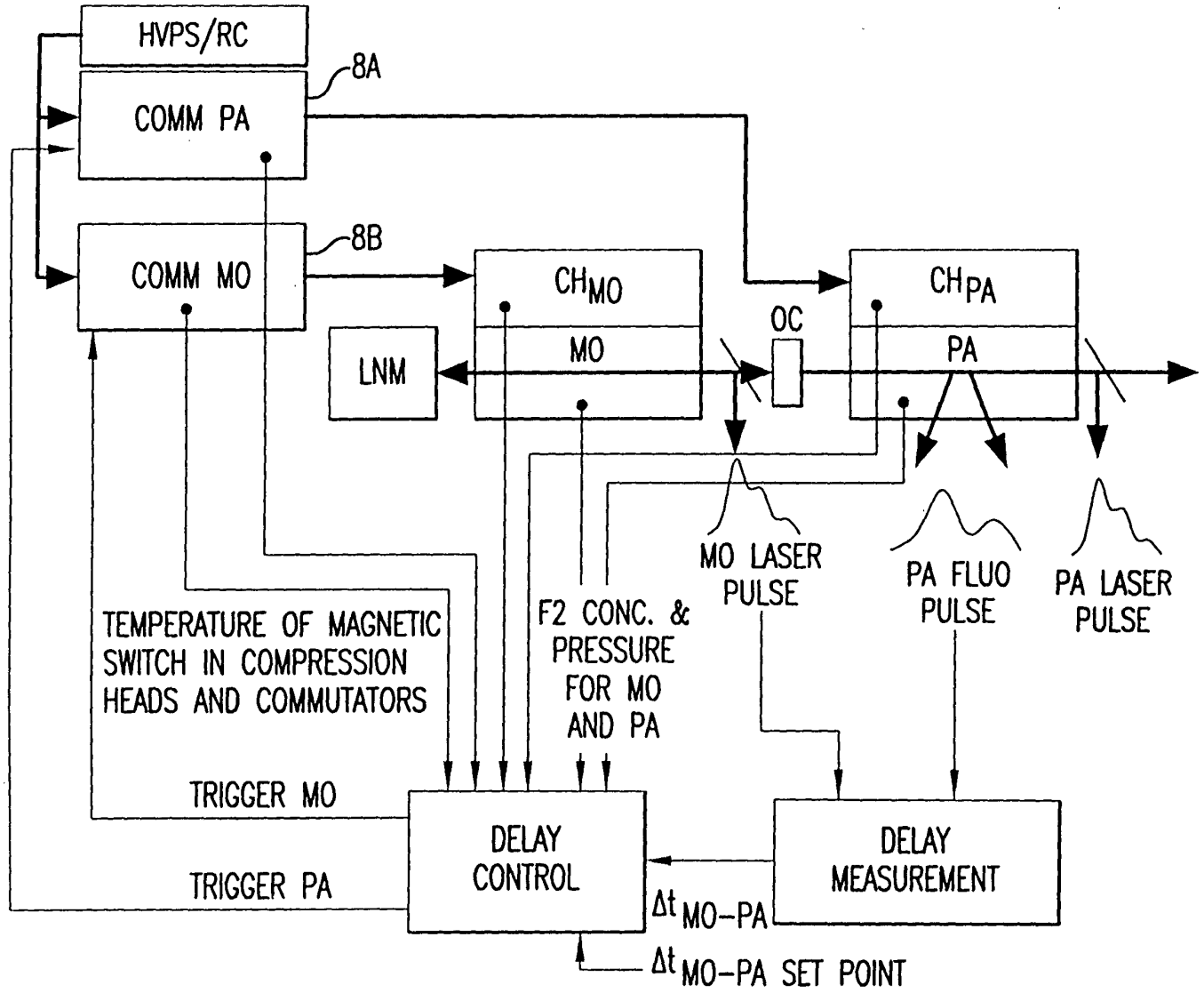

HVPS/RC
8A
COMM PA
8B
COMM MO
CH MO
MO
LNM
OC
CH PA
PA
MO LASER PULSE
PA FLUO PULSE
PA LASER PULSE
TEMPERATURE OF MAGNETIC SWITCH IN COMPRESSION HEADS AND COMMUTATORS
F2 CONC. & PRESSURE FOR MO AND PA
TRIGGER MO
TRIGGER PA
DELAY CONTROL
DELAY MEASUREMENT
Δt MO-PA
Δt MO-PA SET POINT

FIG.4

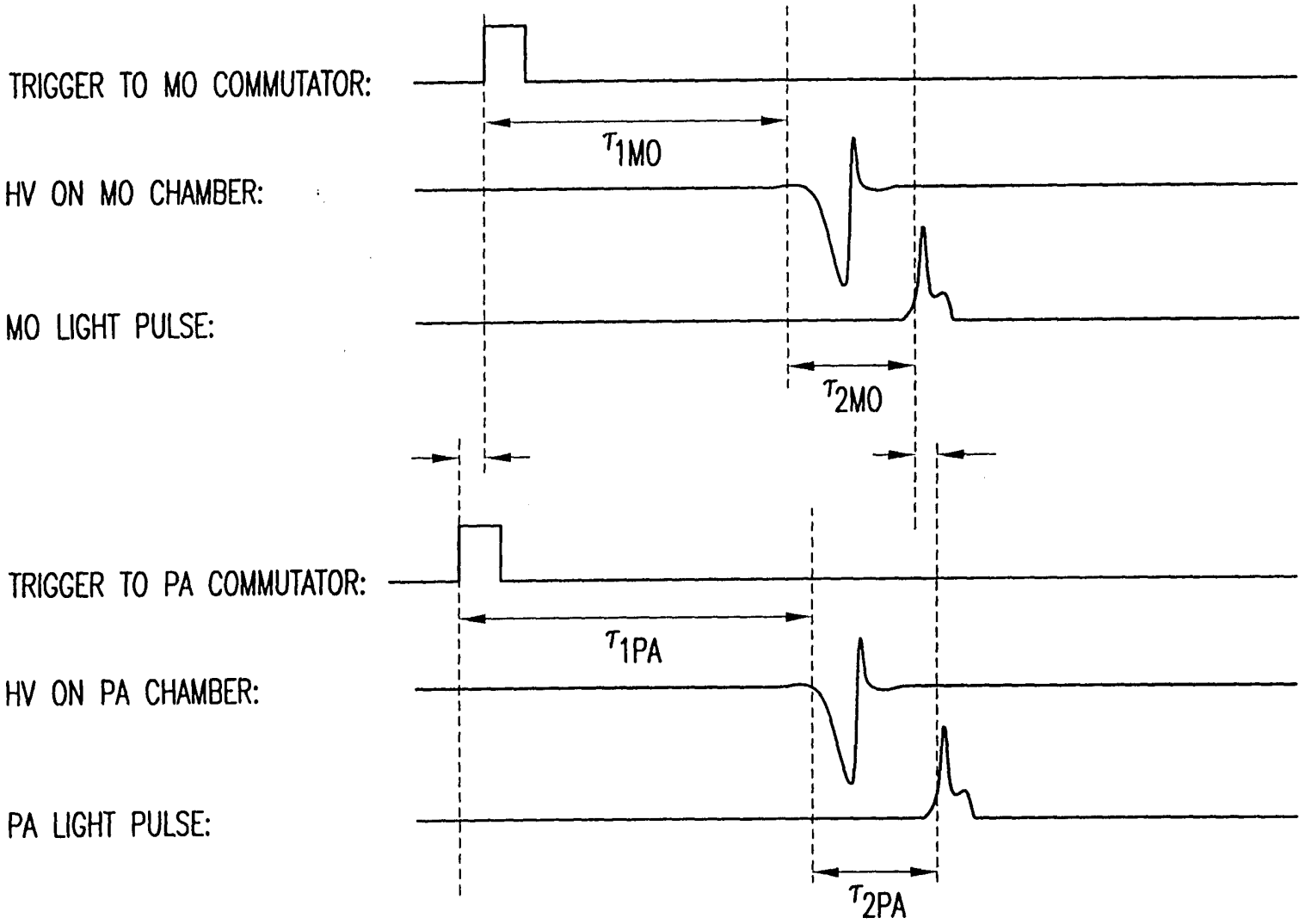

TRIGGER TO MO COMMUTATOR:
τ_{1MO}
HV ON MO CHAMBER:
MO LIGHT PULSE:
τ_{2MO}
TRIGGER TO PA COMMUTATOR:
τ_{1PA}
HV ON PA CHAMBER:
PA LIGHT PULSE:
τ_{2PA}

FIG.4A

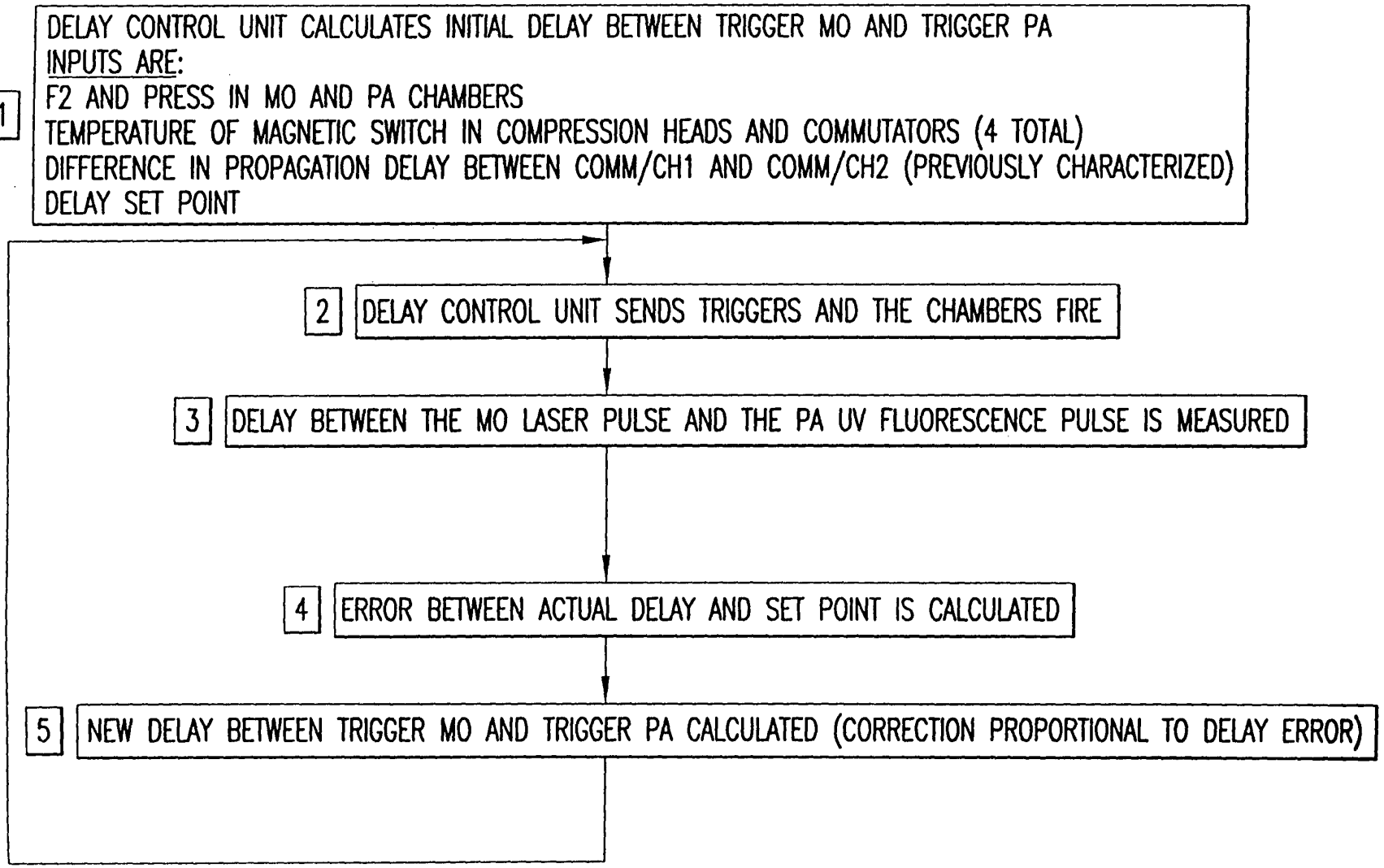

1
DELAY CONTROL UNIT CALCULATES INITIAL DELAY BETWEEN TRIGGER MO AND TRIGGER PA
INPUTS ARE:
F2 AND PRESS IN MO AND PA CHAMBERS
TEMPERATURE OF MAGNETIC SWITCH IN COMPRESSION HEADS AND COMMUTATORS (4 TOTAL)
DIFFERENCE IN PROPAGATION DELAY BETWEEN COMM/CH1 AND COMM/CH2 (PREVIOUSLY CHARACTERIZED)
DELAY SET POINT
2
DELAY CONTROL UNIT SENDS TRIGGERS AND THE CHAMBERS FIRE
3
DELAY BETWEEN THE MO LASER PULSE AND THE PA UV FLUORESCENCE PULSE IS MEASURED
4
ERROR BETWEEN ACTUAL DELAY AND SET POINT IS CALCULATED
5
NEW DELAY BETWEEN TRIGGER MO AND TRIGGER PA CALCULATED (CORRECTION PROPORTIONAL TO DELAY ERROR)

FIG.4B

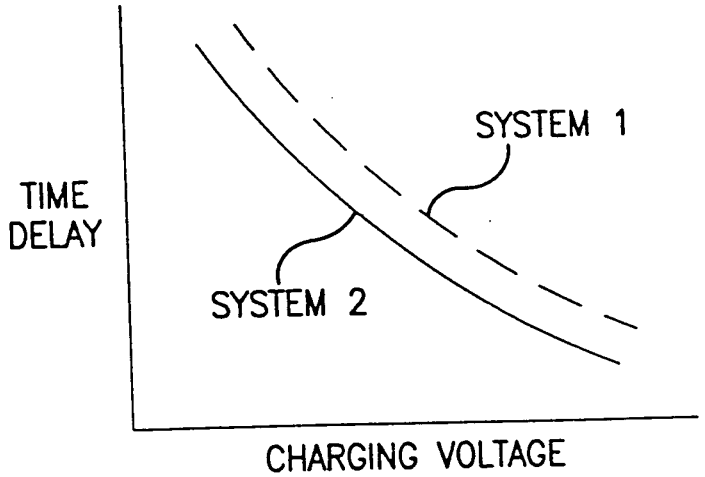


FIG.4C

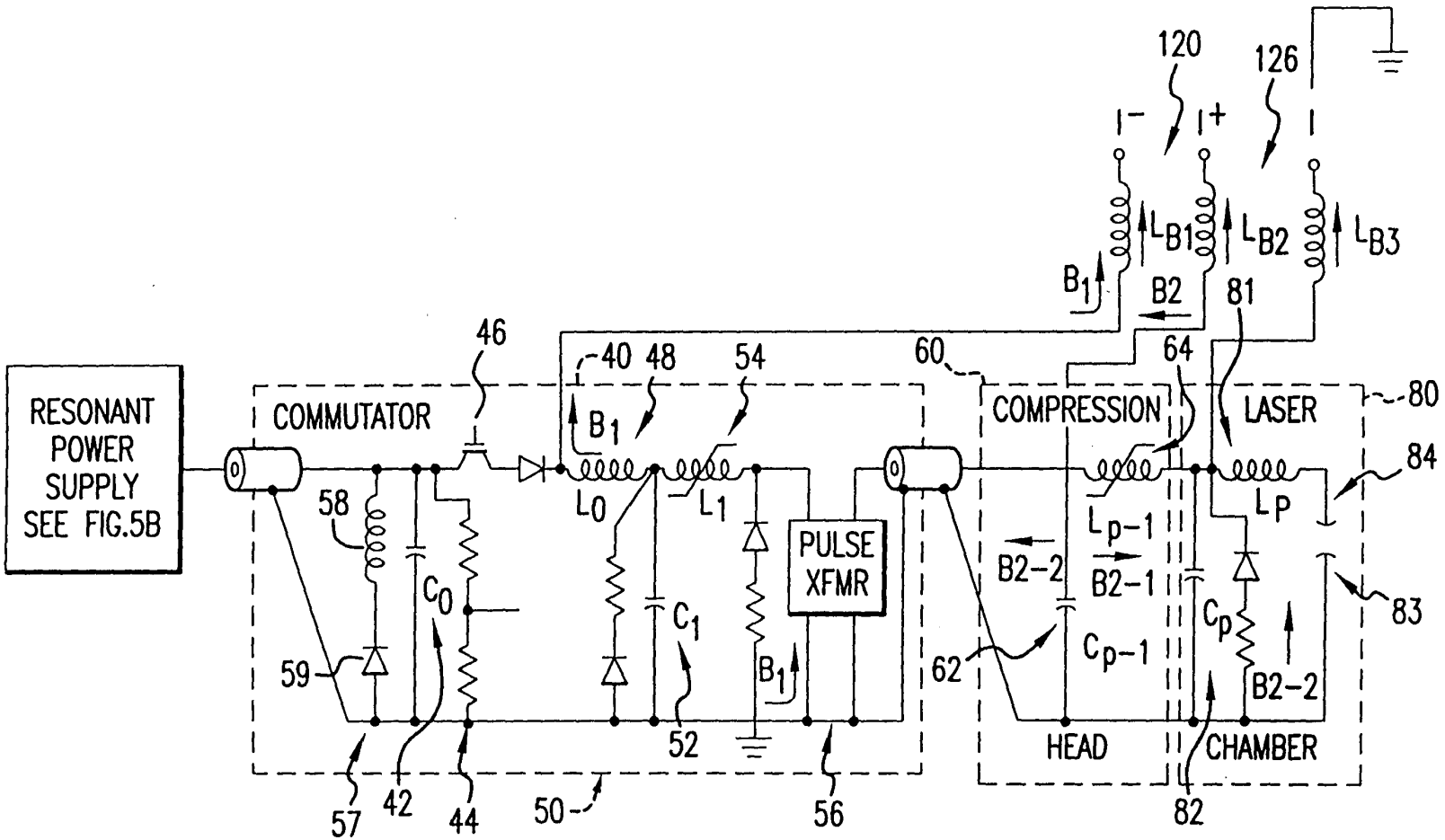

RESONANT
POWER
SUPPLY
SEE FIG.5B
COMMUTATOR
46
40
48
54
60
64
80
120
126
I-
I+
L_{B1}
L_{B2}
L_{B3}
B_1
B2
81
B_1
L_0
L_1
58
C_0
59
C_1
PULSE
XFMR
52
57
42
44
50
56
COMPRESSION
LASER
L_{p-1}
L_P
B2-2
B2-1
C_{p-1}
C_p
62
HEAD
CHAMBER
82
83
84

FIG.5A

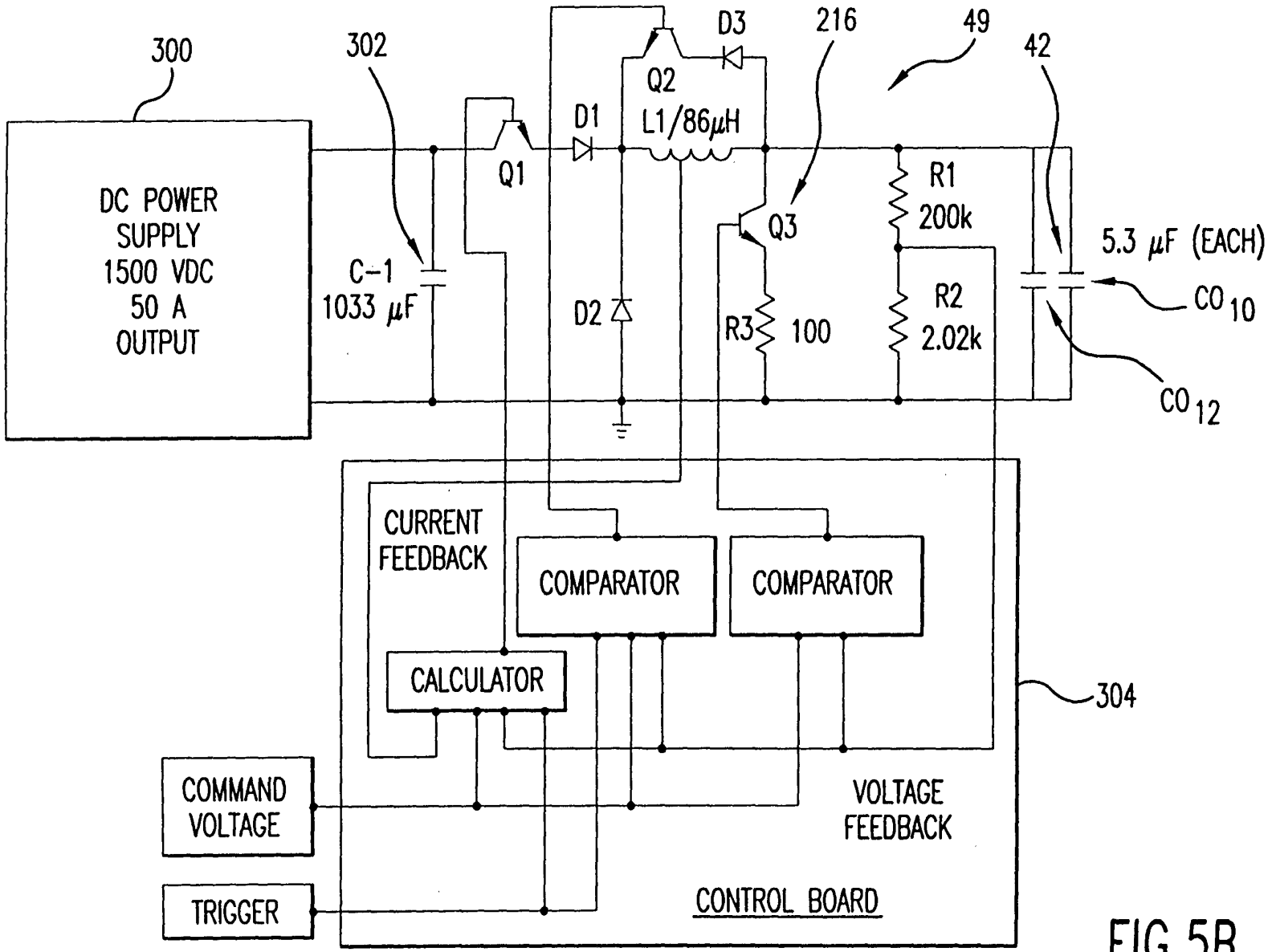

300
302
D3
216
49
42
Q2
L1/86μH
D1
Q1
DC POWER
SUPPLY
1500 VDC
50 A
OUTPUT
C-1
1033 μF
D2
Q3
R1
200k
R2
2.02k
R3
100
5.3 μF (EACH)
CO 10
CO 12
CURRENT
FEEDBACK
COMPARATOR
COMPARATOR
CALCULATOR
304
COMMAND
VOLTAGE
TRIGGER
VOLTAGE
FEEDBACK
CONTROL BOARD

FIG.5B

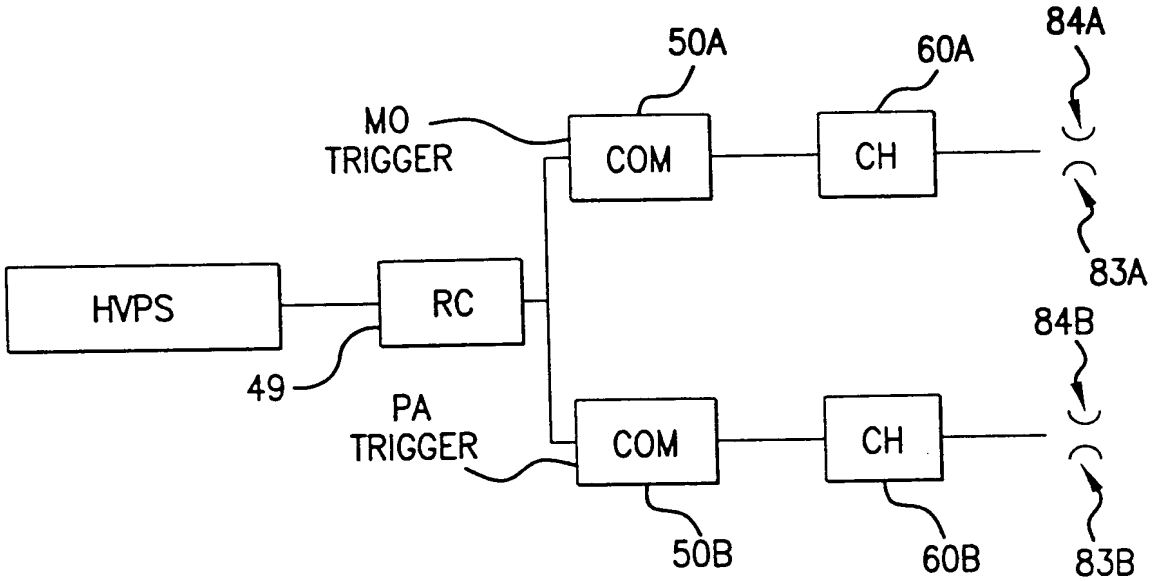


FIG.5C1

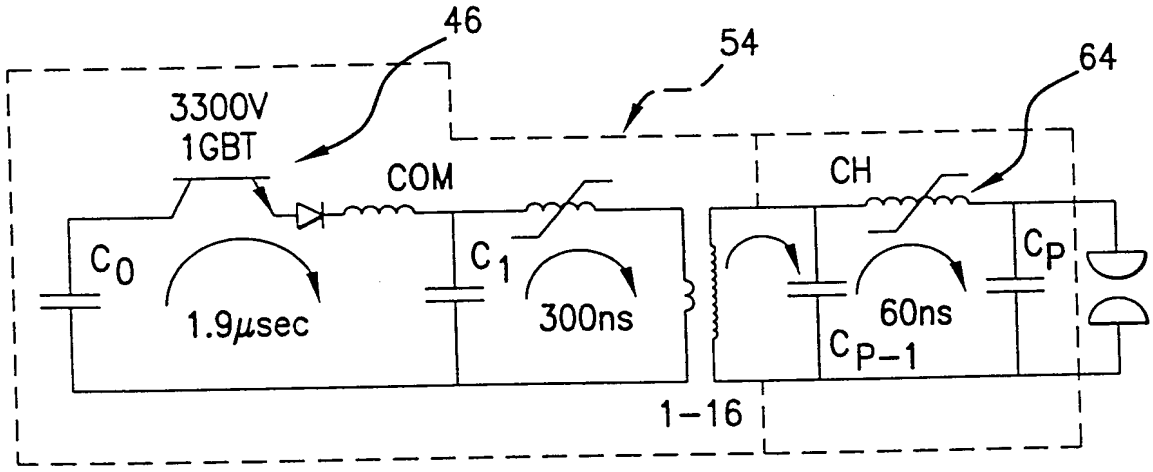


FIG.5C2

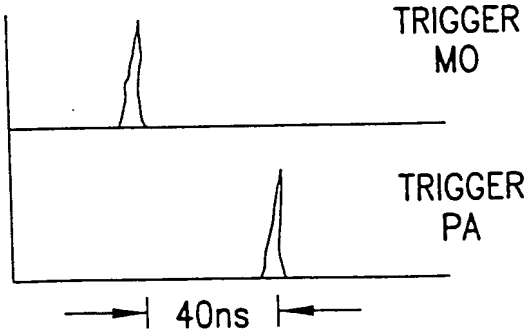


FIG.5C3

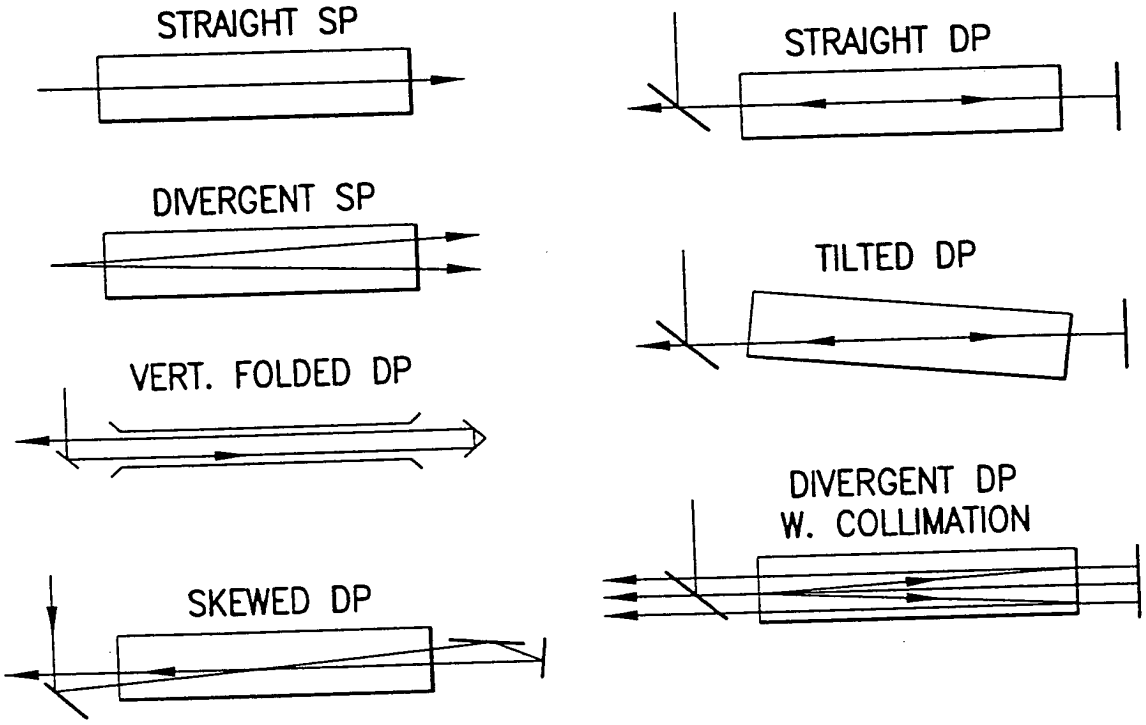

STRAIGHT SP
STRAIGHT DP
DIVERGENT SP
TILTED DP
VERT. FOLDED DP
DIVERGENT DP
W. COLLIMATION
SKEWED DP

FIG.6A1

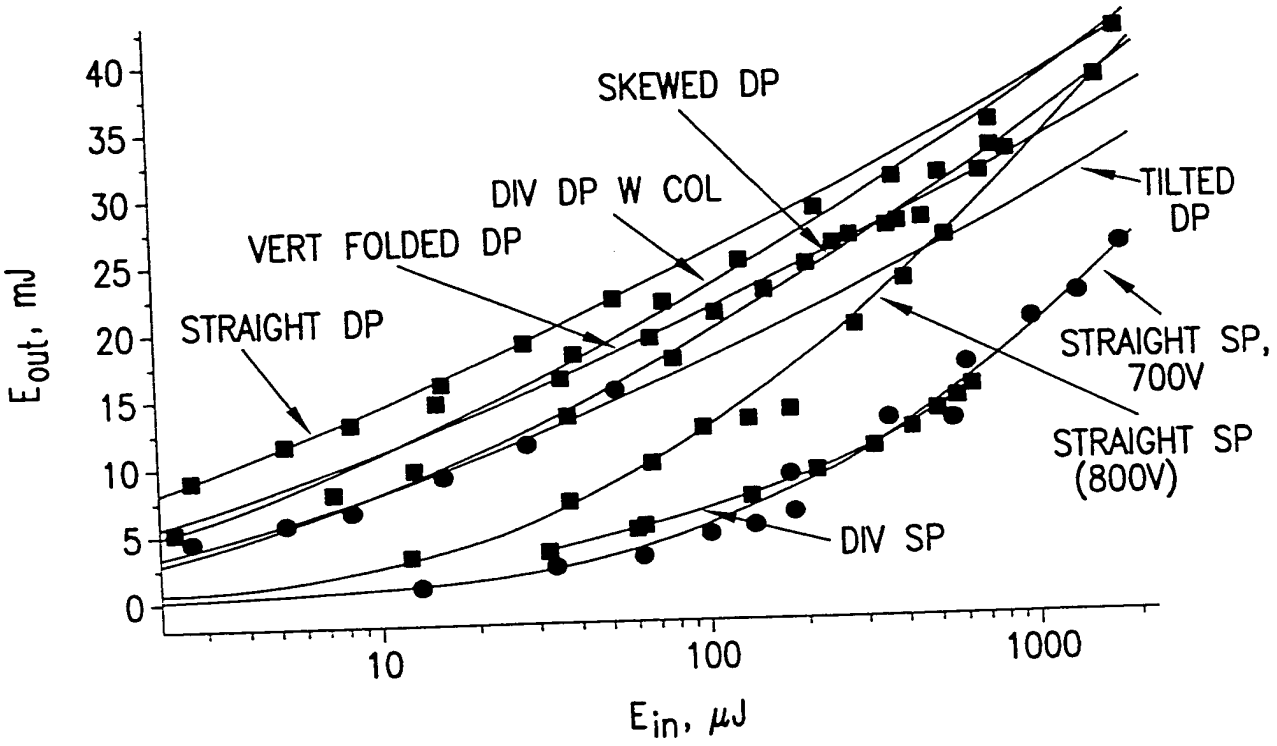

40
35
30
25
20
15
10
5
0
E_{out}, mJ
10
100
1000
E_{in}, μJ
SKEWED DP
DIV DP W COL
VERT FOLDED DP
STRAIGHT DP
TILTED DP
STRAIGHT SP, 700V
STRAIGHT SP (800V)
DIV SP

FIG.6A2

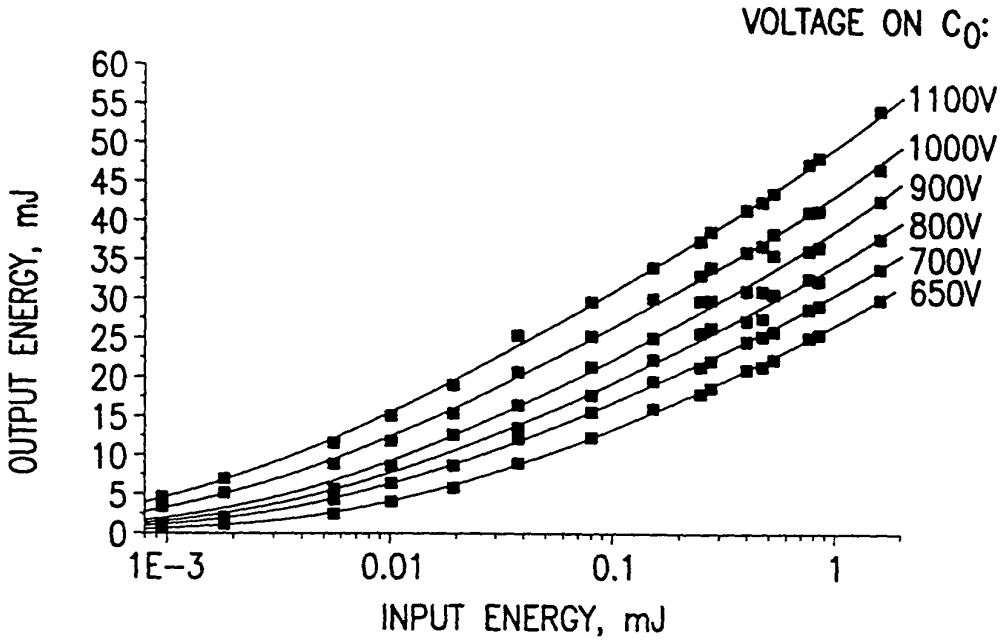

VOLTAGE ON C_0:
1100V
1000V
900V
800V
700V
650V
OUTPUT ENERGY, mJ
60
55
50
45
40
35
30
25
20
15
10
5
0
1E-3
0.01
0.1
1
INPUT ENERGY, mJ

FIG.6B

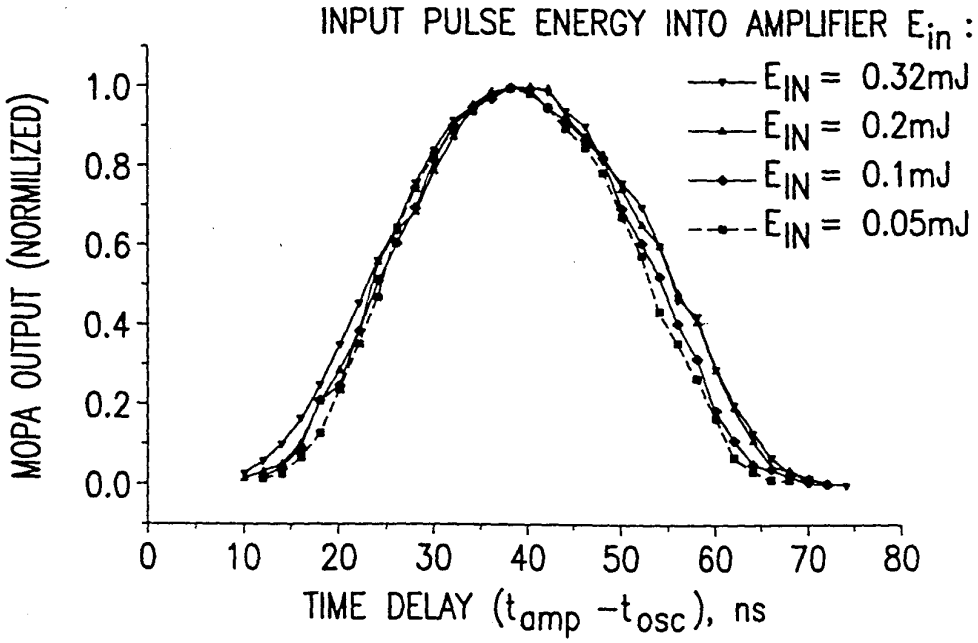

INPUT PULSE ENERGY INTO AMPLIFIER E_{in} :
E_{IN} = 0.32mJ
E_{IN} = 0.2mJ
E_{IN} = 0.1mJ
E_{IN} = 0.05mJ
MOPA OUTPUT (NORMILIZED)
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
60
70
80
TIME DELAY ($t_{amp} - t_{osc}$), ns

FIG.6C

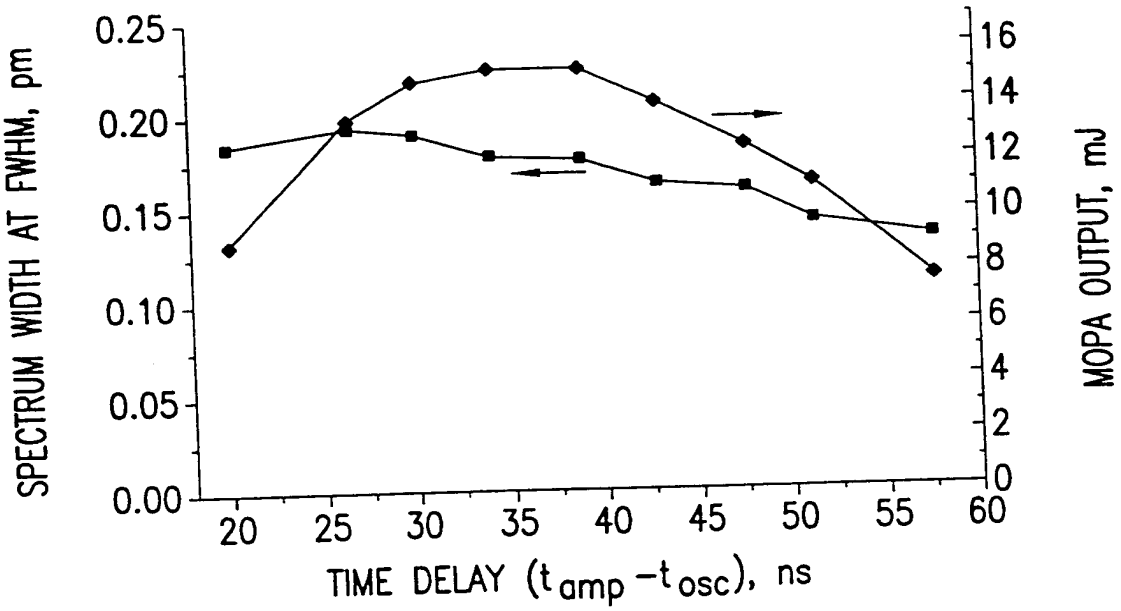

SPECTRUM WIDTH AT FWHM, pm
0.25
0.20
0.15
0.10
0.05
0.00
16
14
12
10
8
6
4
2
0
MOPA OUTPUT, mJ
20
25
30
35
40
45
50
55
60
TIME DELAY ($t_{amp} - t_{osc}$), ns

FIG.6D

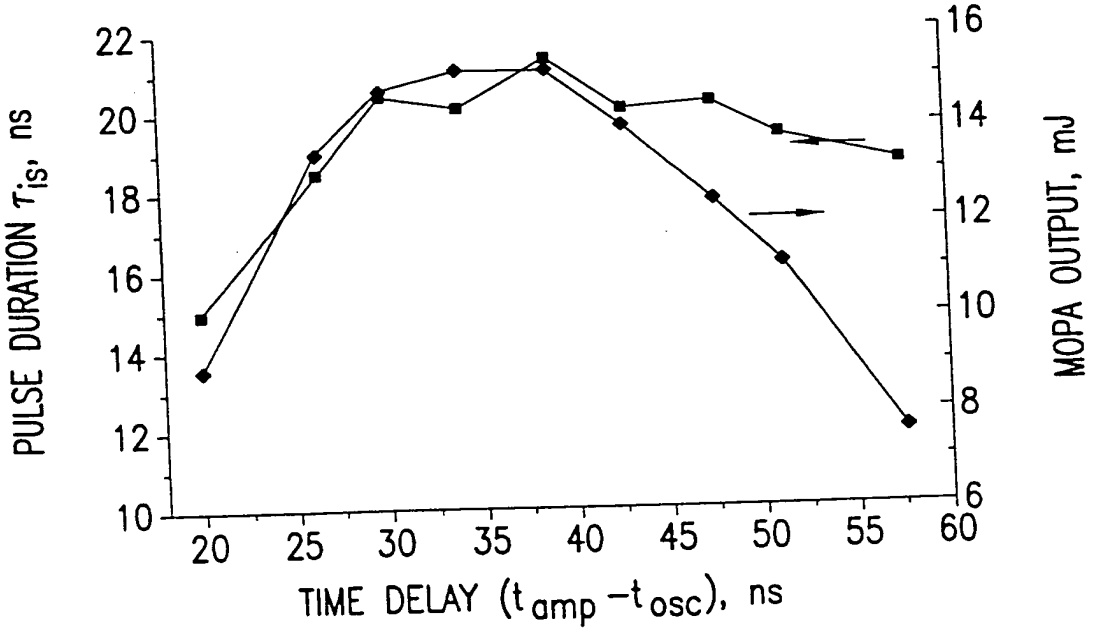

PULSE DURATION τ_{is}, ns
22
20
18
16
14
12
10
16
14
12
10
8
6
MOPA OUTPUT, mJ
20
25
30
35
40
45
50
55
60
TIME DELAY ($t_{amp} - t_{osc}$), ns

FIG.6E

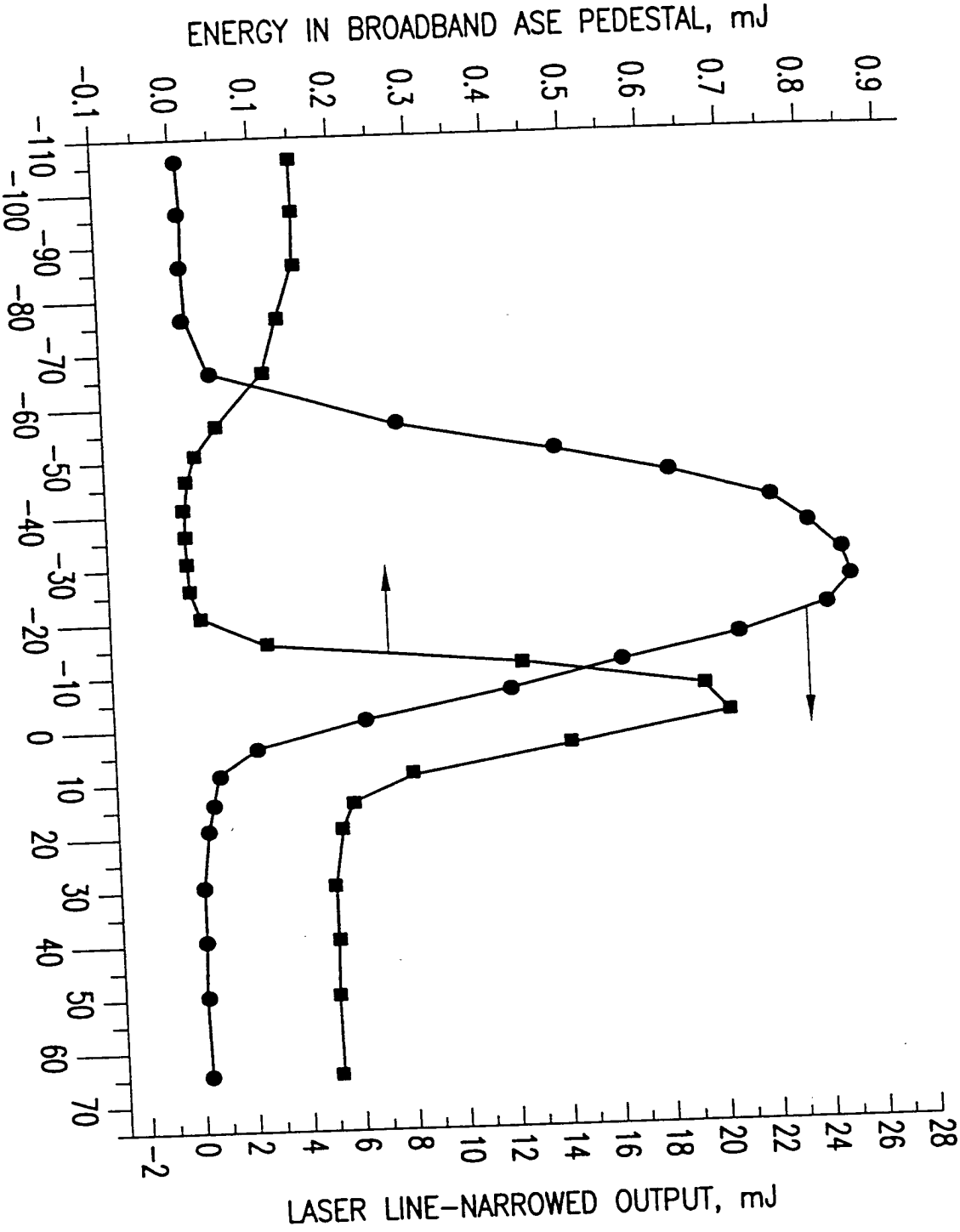

ENERGY IN BROADBAND ASE PEDESTAL, mJ
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
-110
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
TIME DELAY ($T_{MO}-T_{PA}$), ns
-2
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
LASER LINE-NARROWED OUTPUT, mJ

FIG.6F

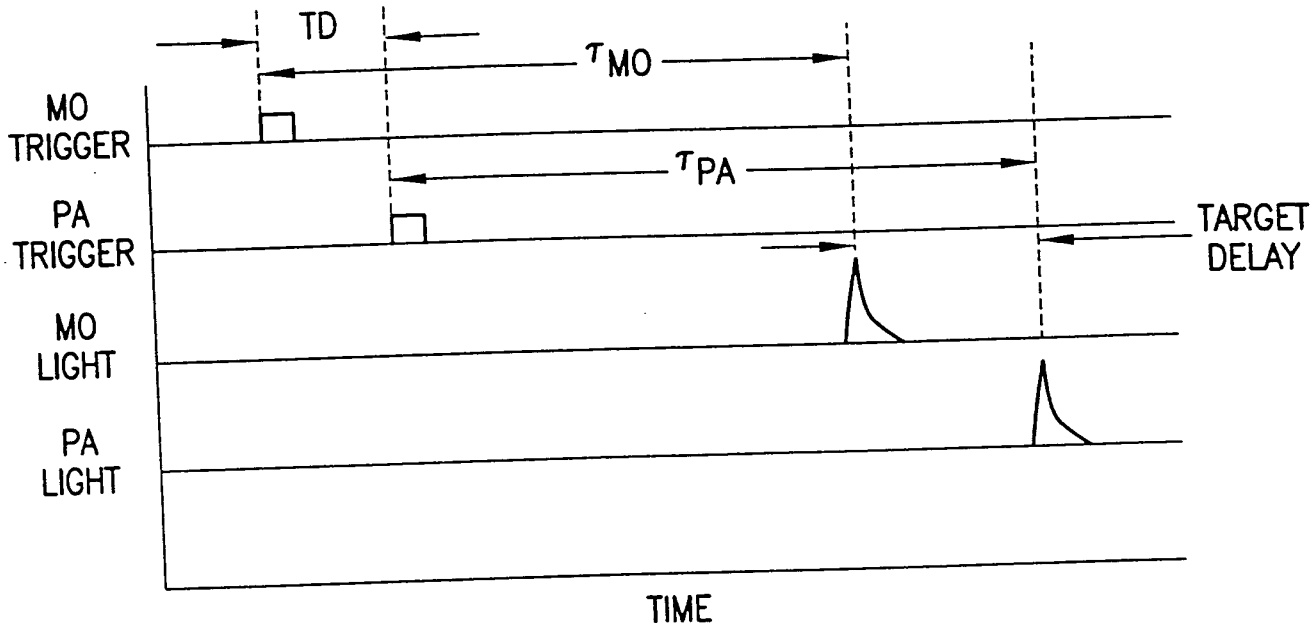

TD
τ_{MO}
τ_{PA}
MO TRIGGER
PA TRIGGER
MO LIGHT
PA LIGHT
TARGET DELAY
TIME

FIG.6F-1

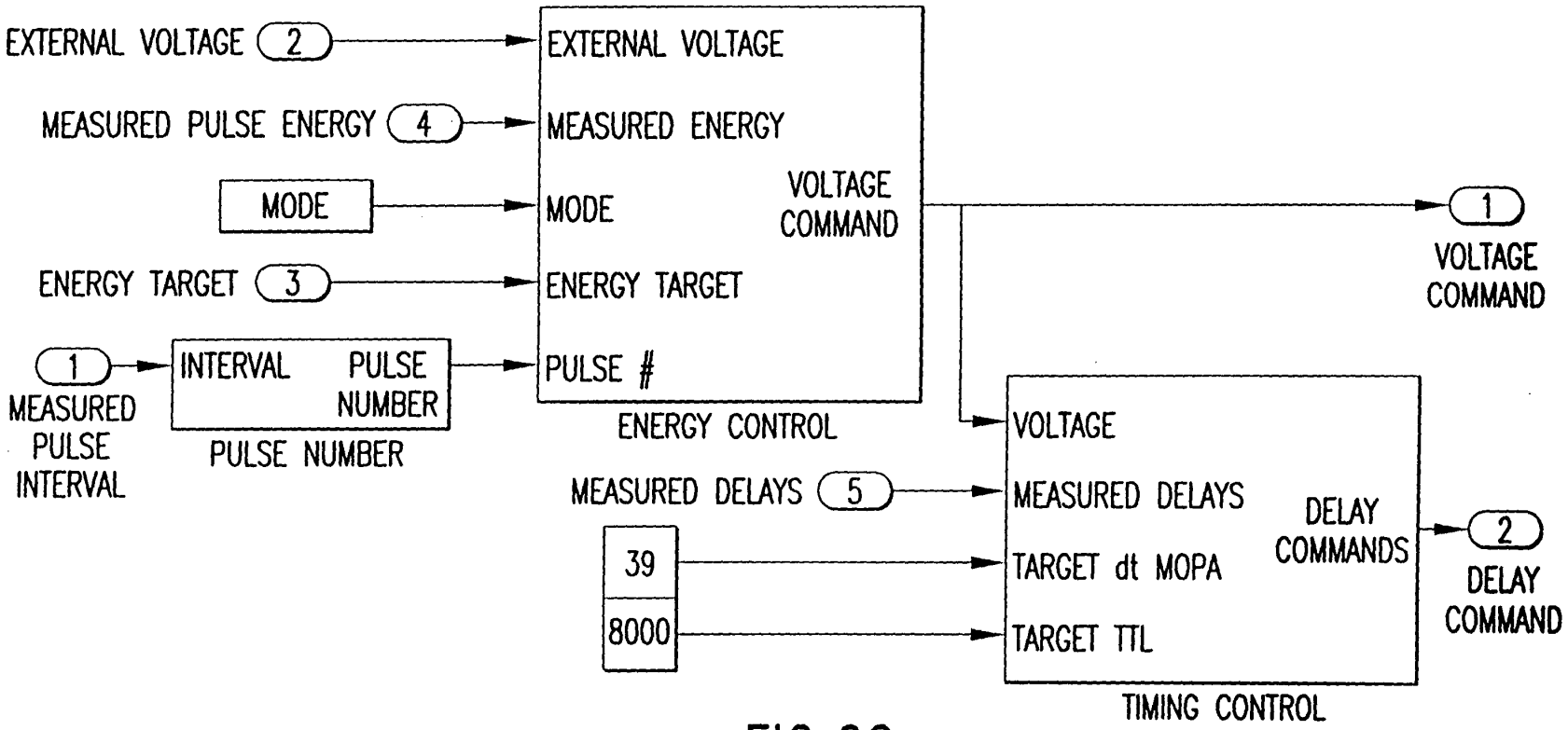

EXTERNAL VOLTAGE
2
MEASURED PULSE ENERGY
4
MODE
ENERGY TARGET
3
1
MEASURED PULSE INTERVAL
INTERVAL
PULSE NUMBER
PULSE NUMBER
EXTERNAL VOLTAGE
MEASURED ENERGY
MODE
ENERGY TARGET
PULSE #
VOLTAGE COMMAND
ENERGY CONTROL
1
VOLTAGE COMMAND
VOLTAGE
MEASURED DELAYS
5
39
8000
MEASURED DELAYS
TARGET dt MOPA
TARGET TTL
DELAY COMMANDS
TIMING CONTROL
2
DELAY COMMAND

FIG.6G

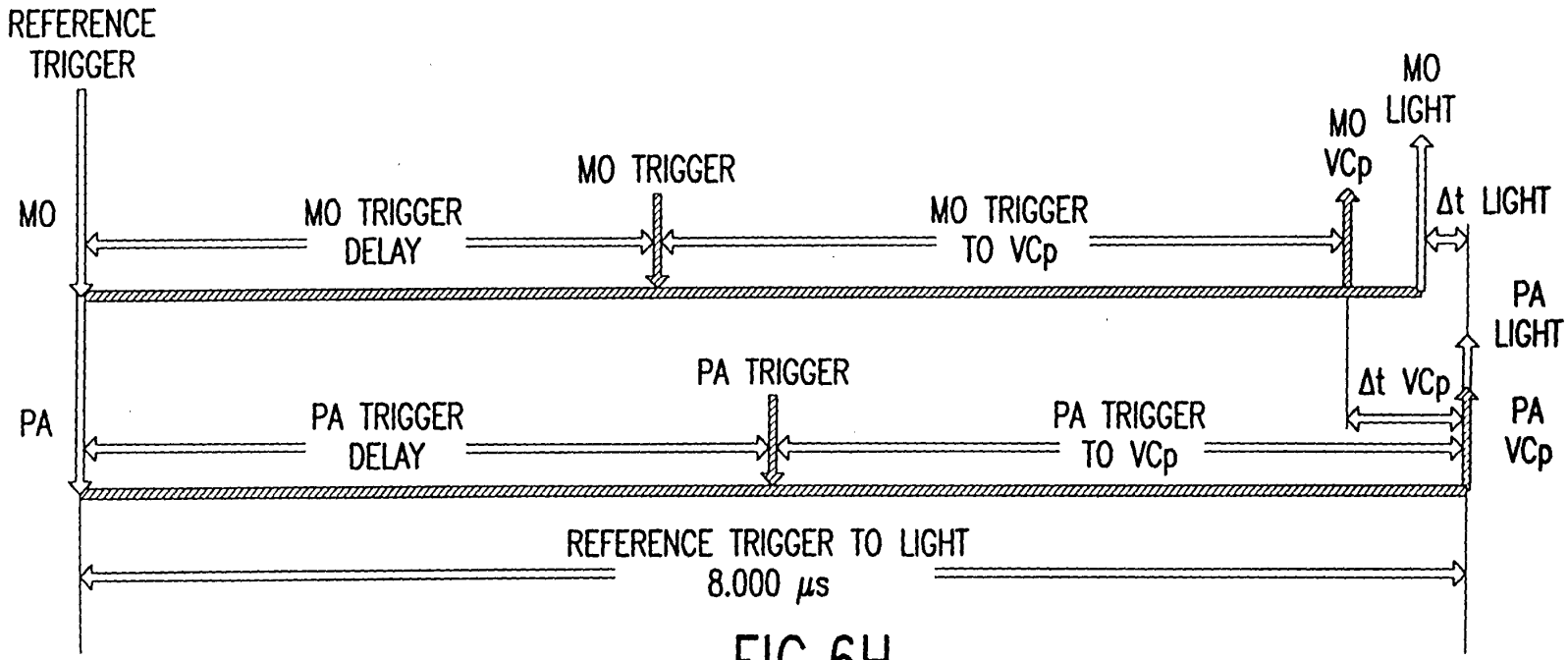

REFERENCE TRIGGER
MO
MO TRIGGER DELAY
MO TRIGGER
MO TRIGGER TO VCp
MO VCp
MO LIGHT
Δt LIGHT
PA LIGHT
PA
PA TRIGGER DELAY
PA TRIGGER
PA TRIGGER TO VCp
Δt VCp
PA VCp
REFERENCE TRIGGER TO LIGHT
8.000 μs

FIG.6H

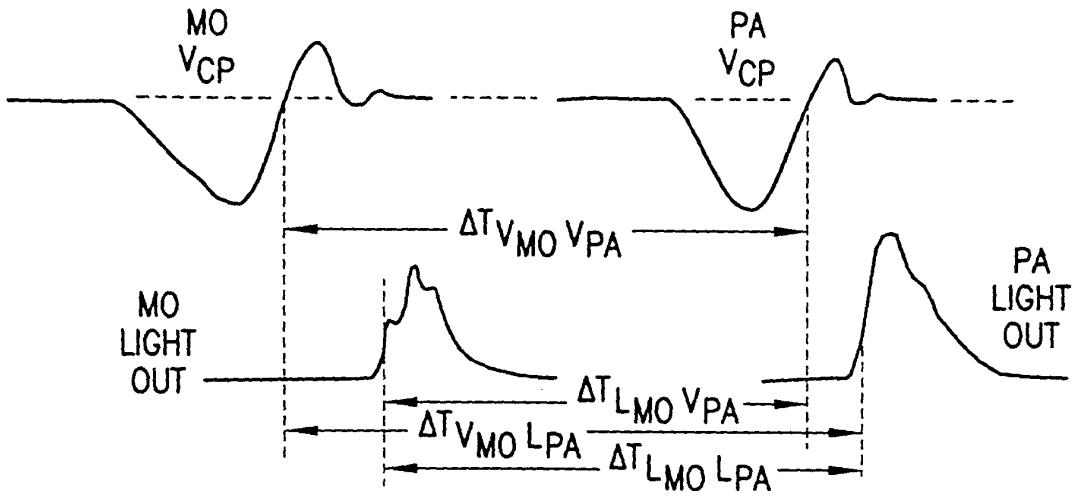

MO
V_{CP}
PA
V_{CP}
$\Delta T_{V_{MO} V_{PA}}$
MO
LIGHT
OUT
PA
LIGHT
OUT
$\Delta T_{L_{MO} V_{PA}}$
$\Delta T_{V_{MO} L_{PA}}$
$\Delta T_{L_{MO} L_{PA}}$

FIG.6J

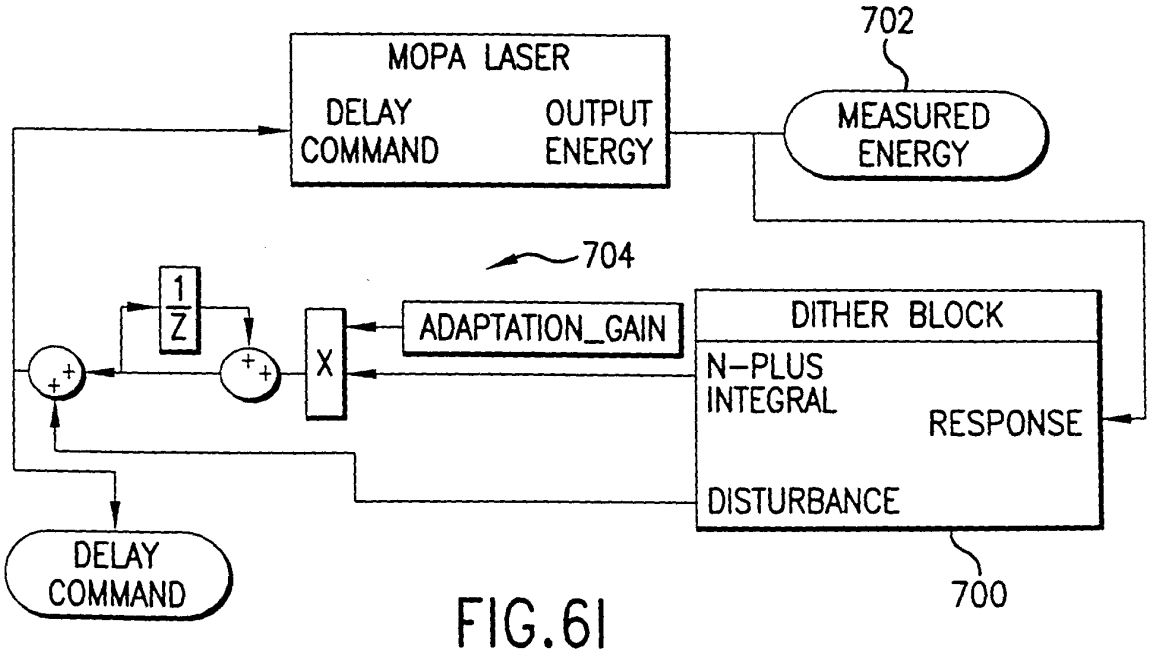

MOPA LASER
DELAY
COMMAND
OUTPUT
ENERGY
702
MEASURED
ENERGY
704
1
Z
X
ADAPTATION_GAIN
DITHER BLOCK
N-PLUS
INTEGRAL
RESPONSE
DISTURBANCE
DELAY
COMMAND
700

FIG.6I

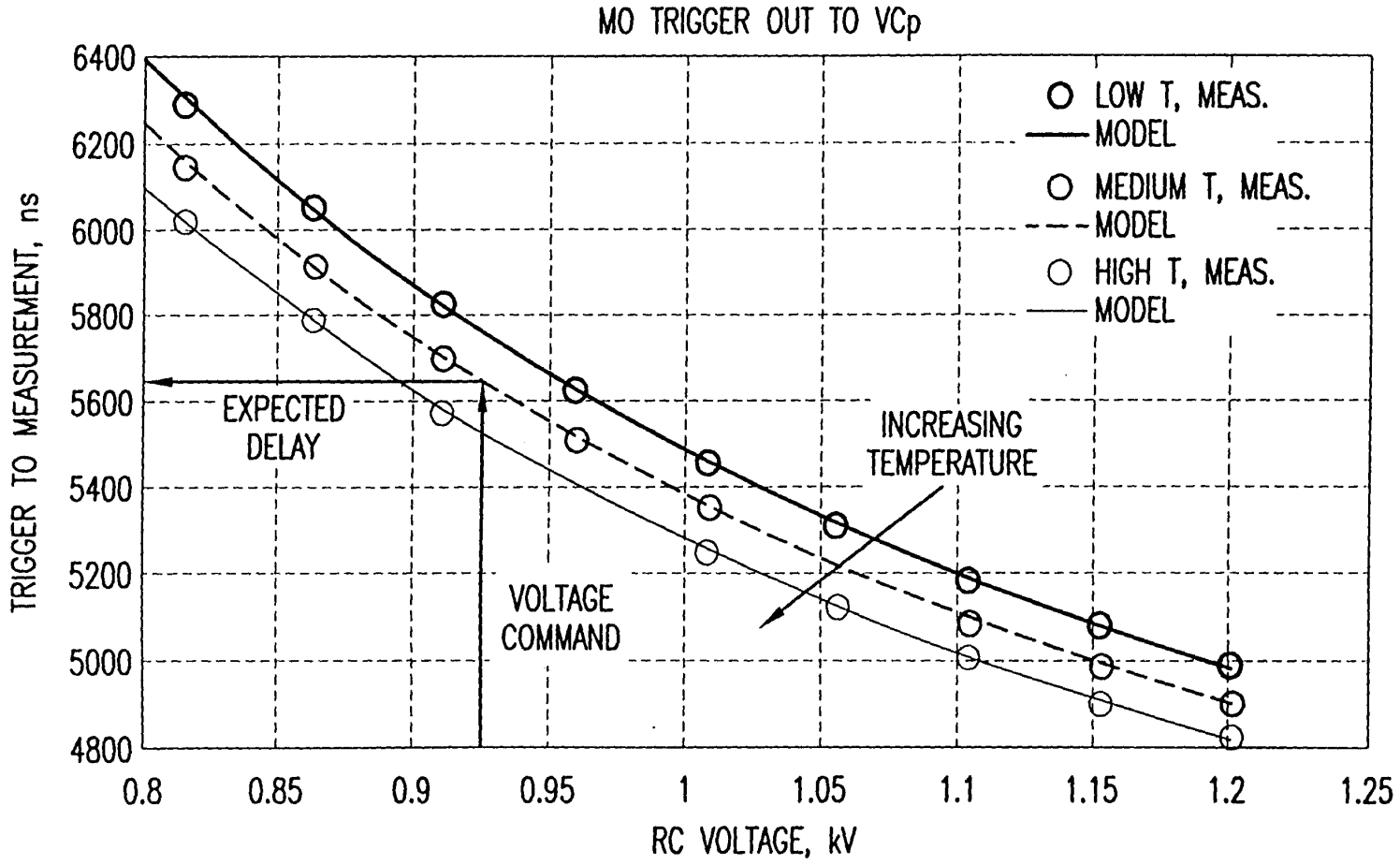

MO TRIGGER OUT TO VCp
TRIGGER TO MEASUREMENT, ns
6400
6200
6000
5800
5600
5400
5200
5000
4800
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2
1.25
RC VOLTAGE, kV
LOW T, MEAS.
MODEL
MEDIUM T, MEAS.
MODEL
HIGH T, MEAS.
MODEL
EXPECTED DELAY
VOLTAGE COMMAND
INCREASING TEMPERATURE

FIG.6K

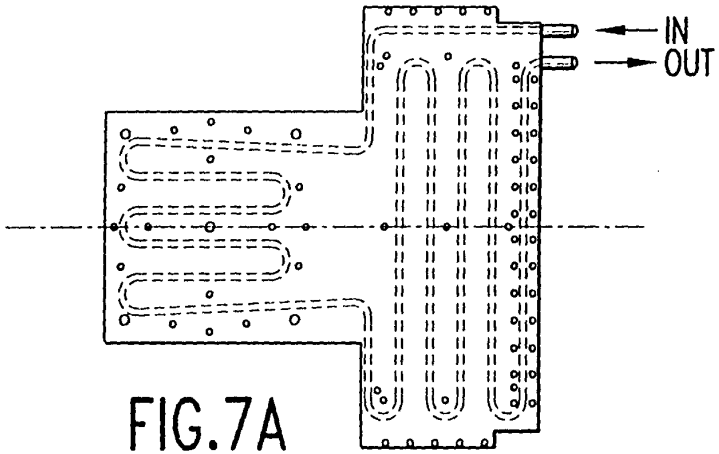


FIG.7A

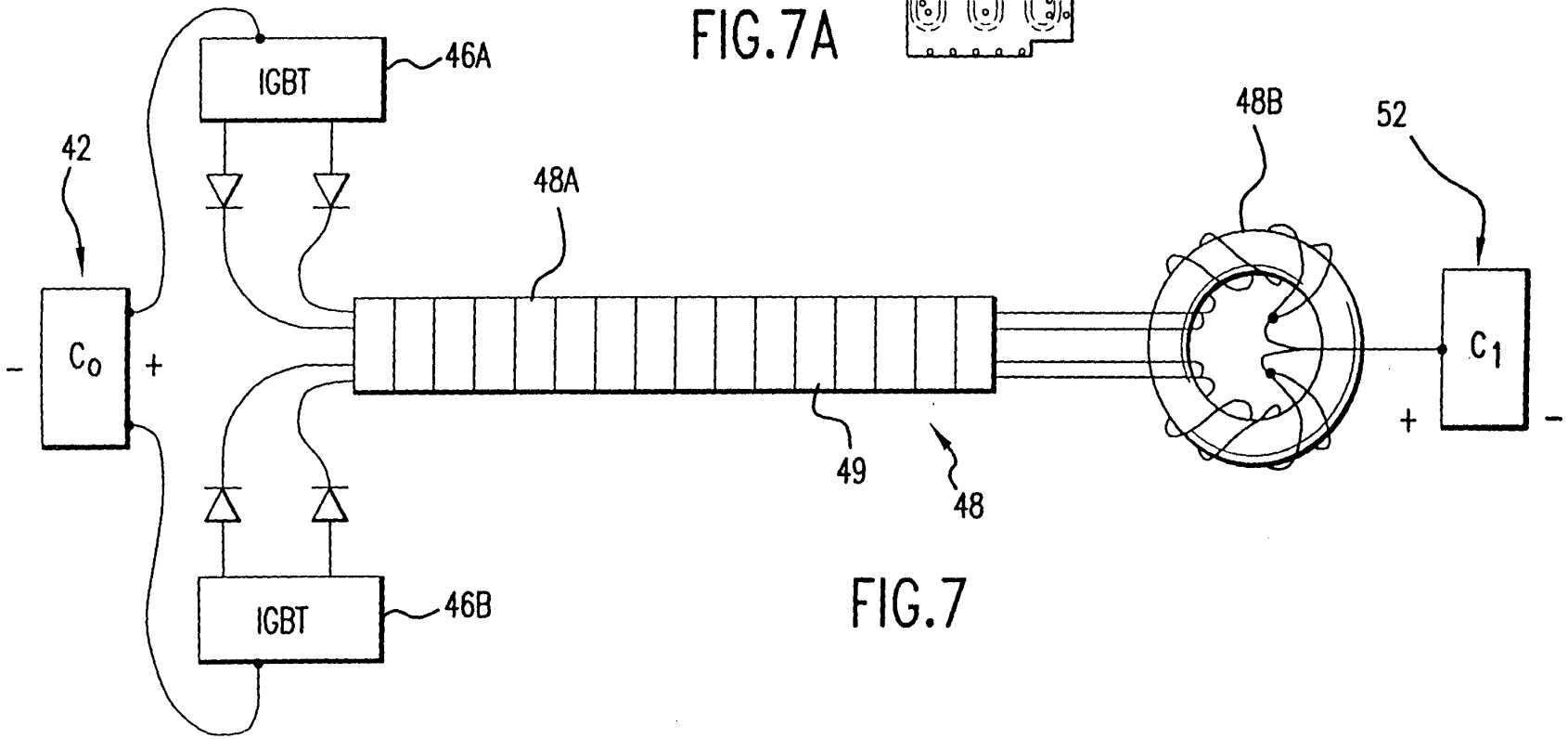


FIG.7

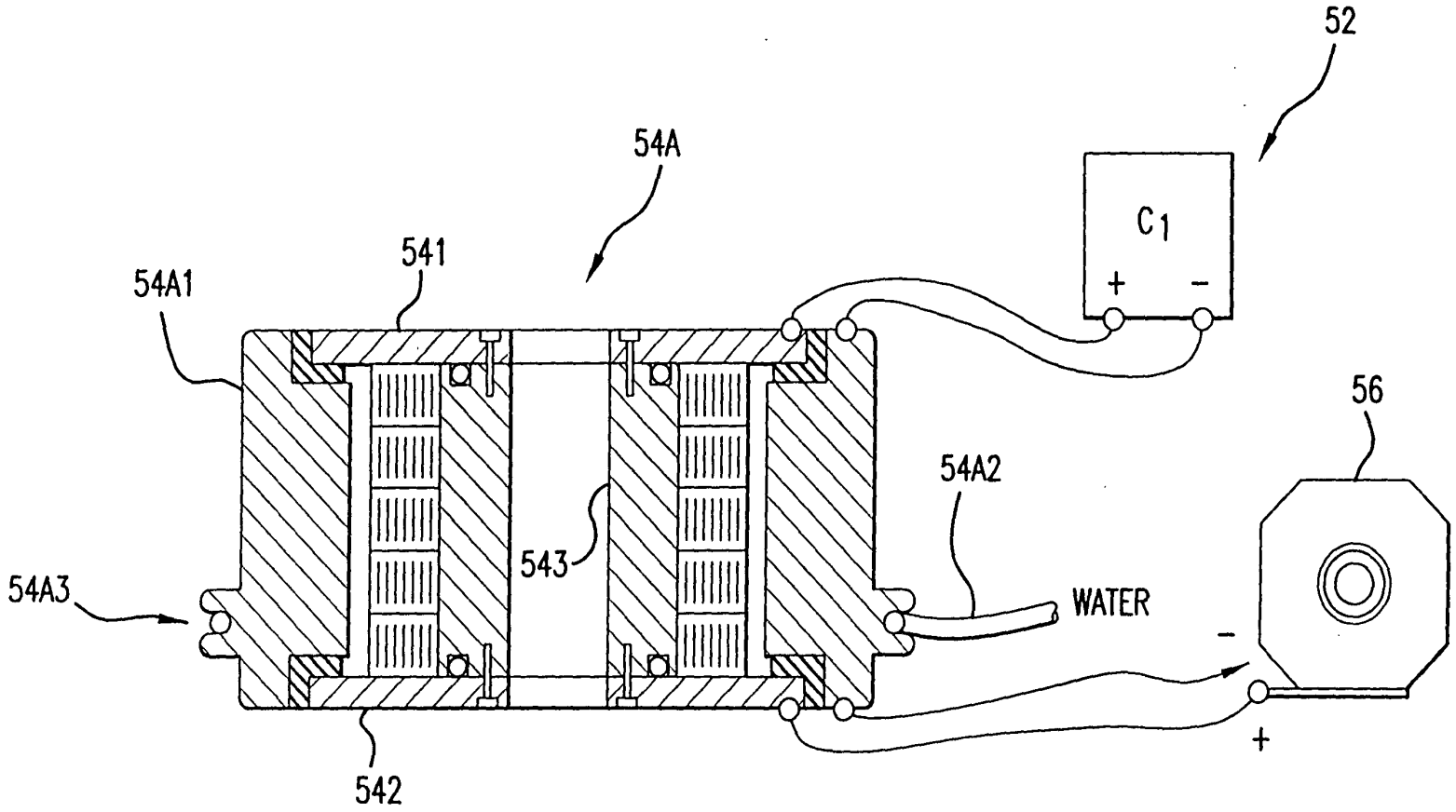


FIG.8

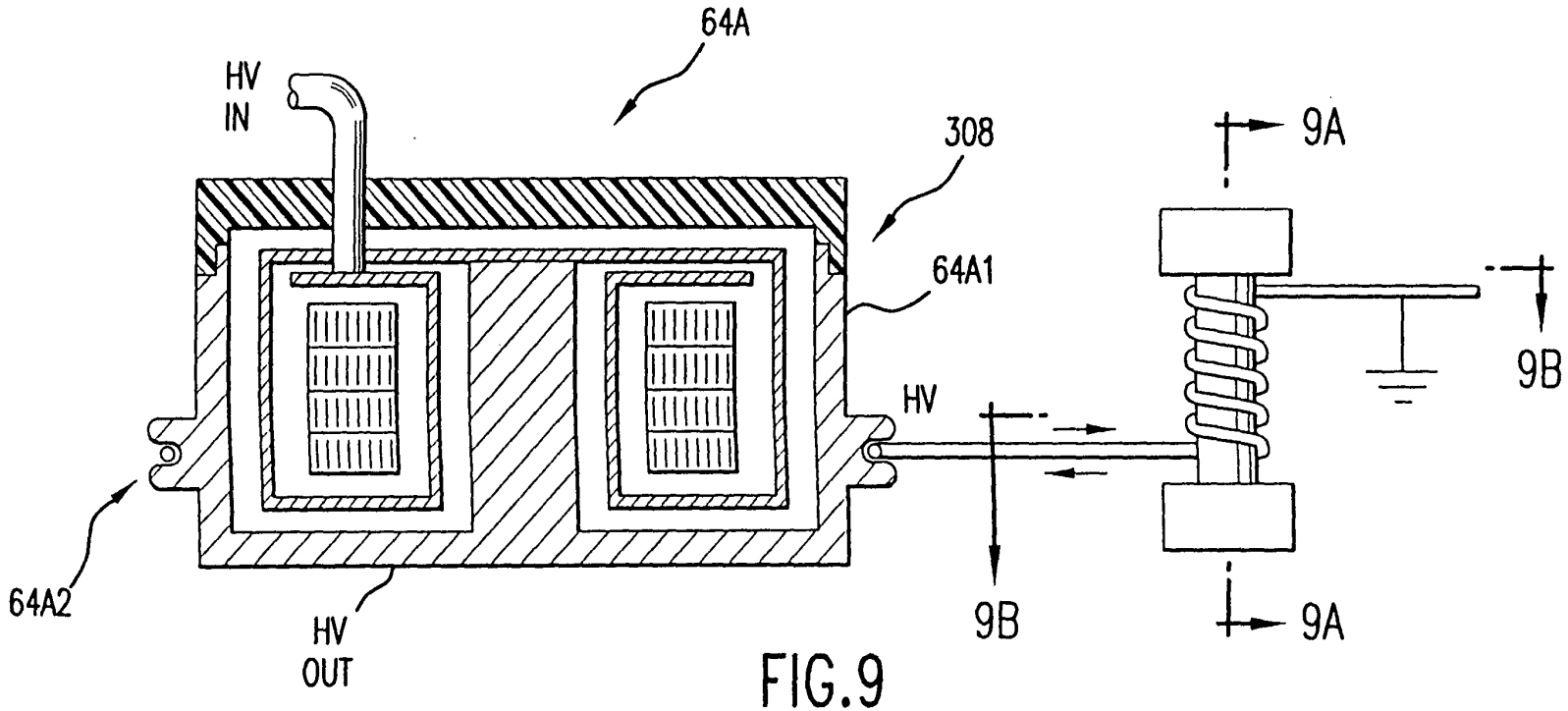


FIG.9

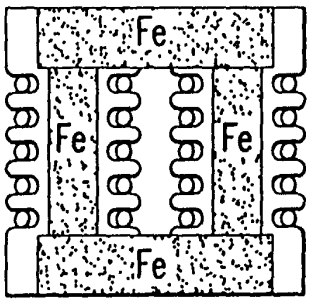


FIG.9A

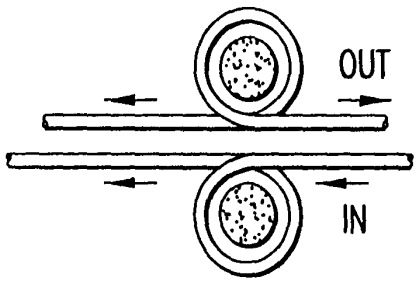


FIG.9B

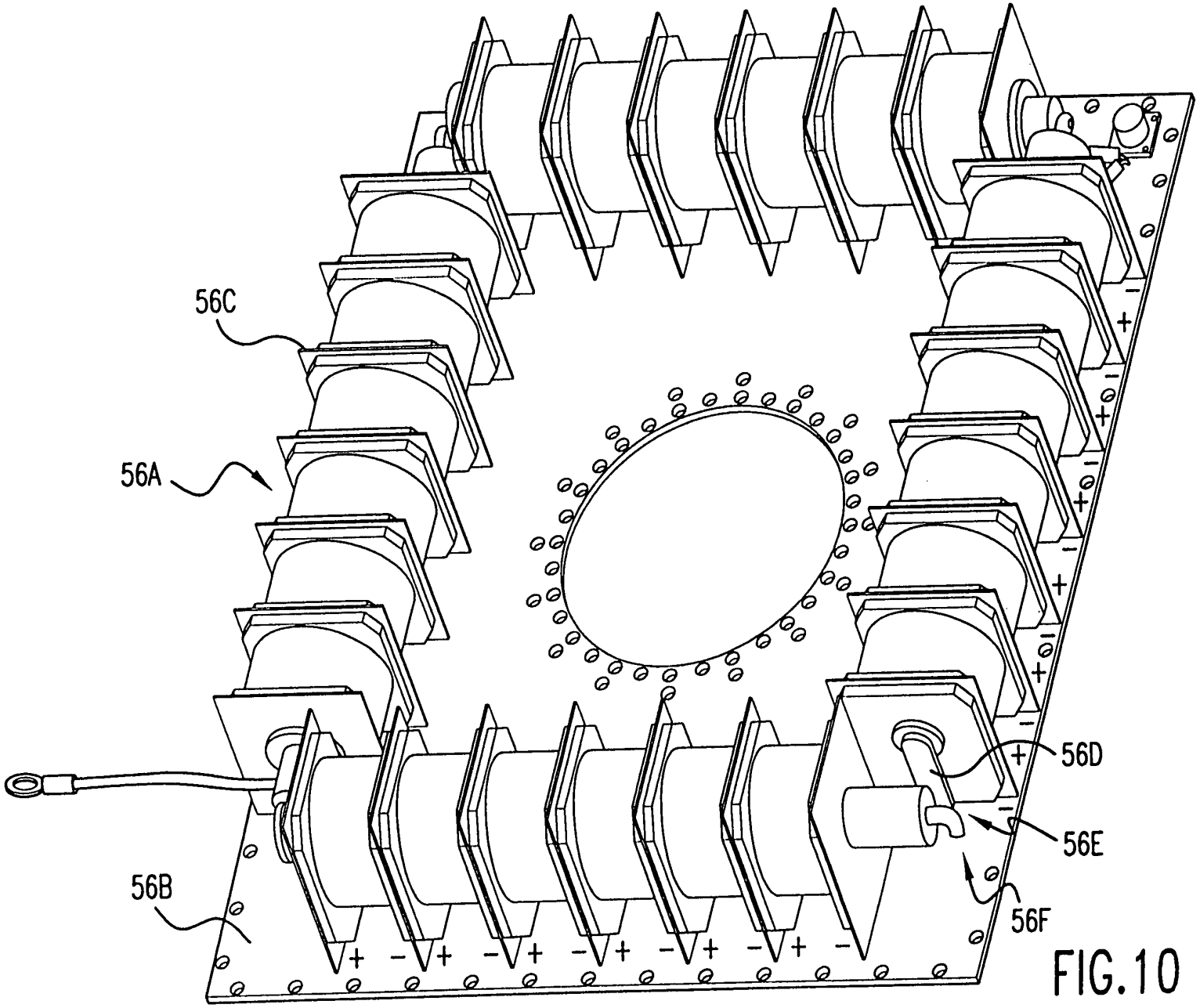


FIG.10

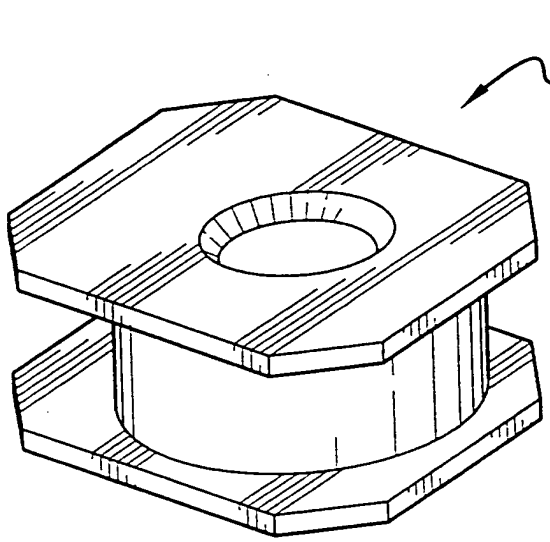


FIG.10A

Timing Control Layers

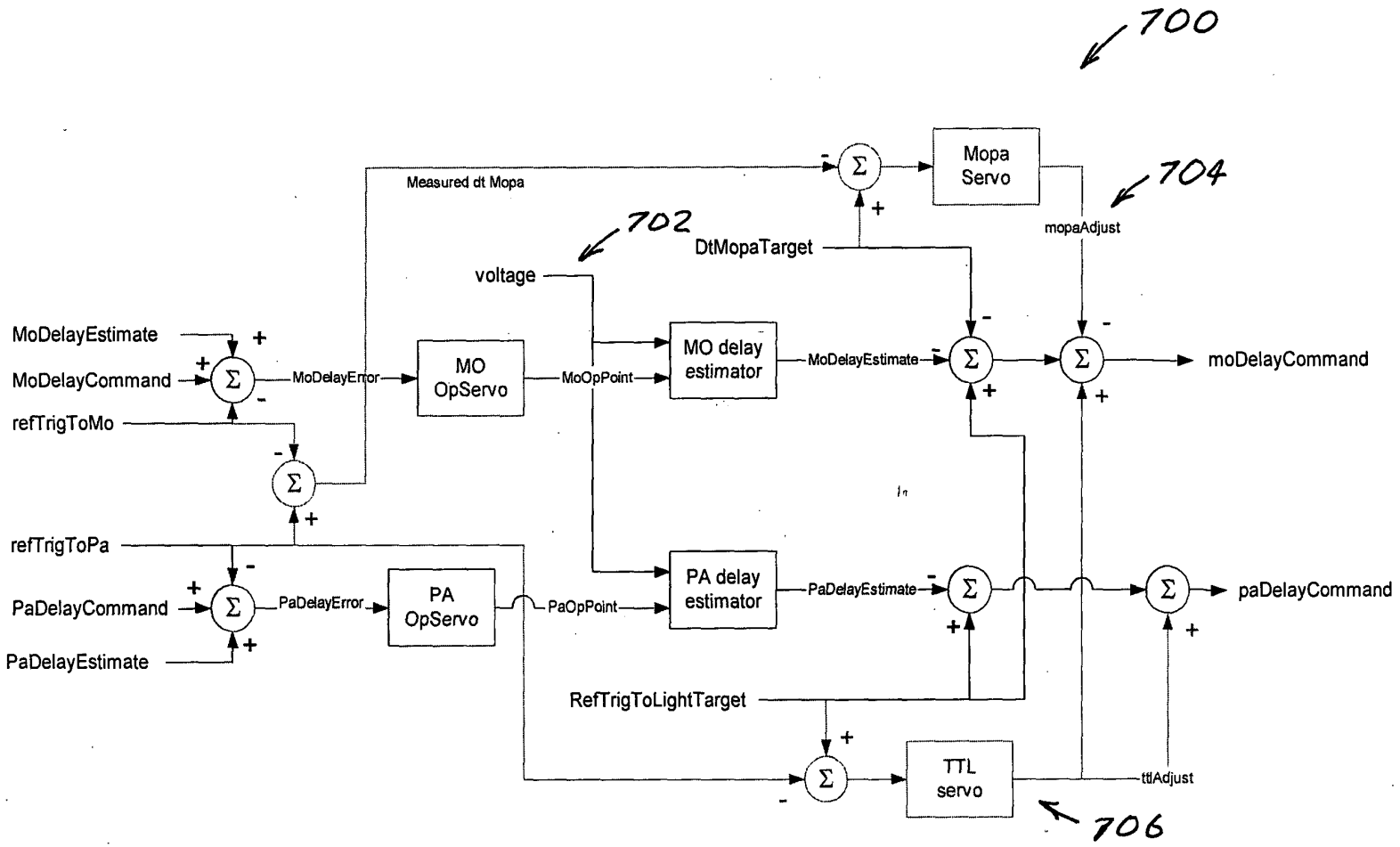


FIG. 11A

Energy control layers

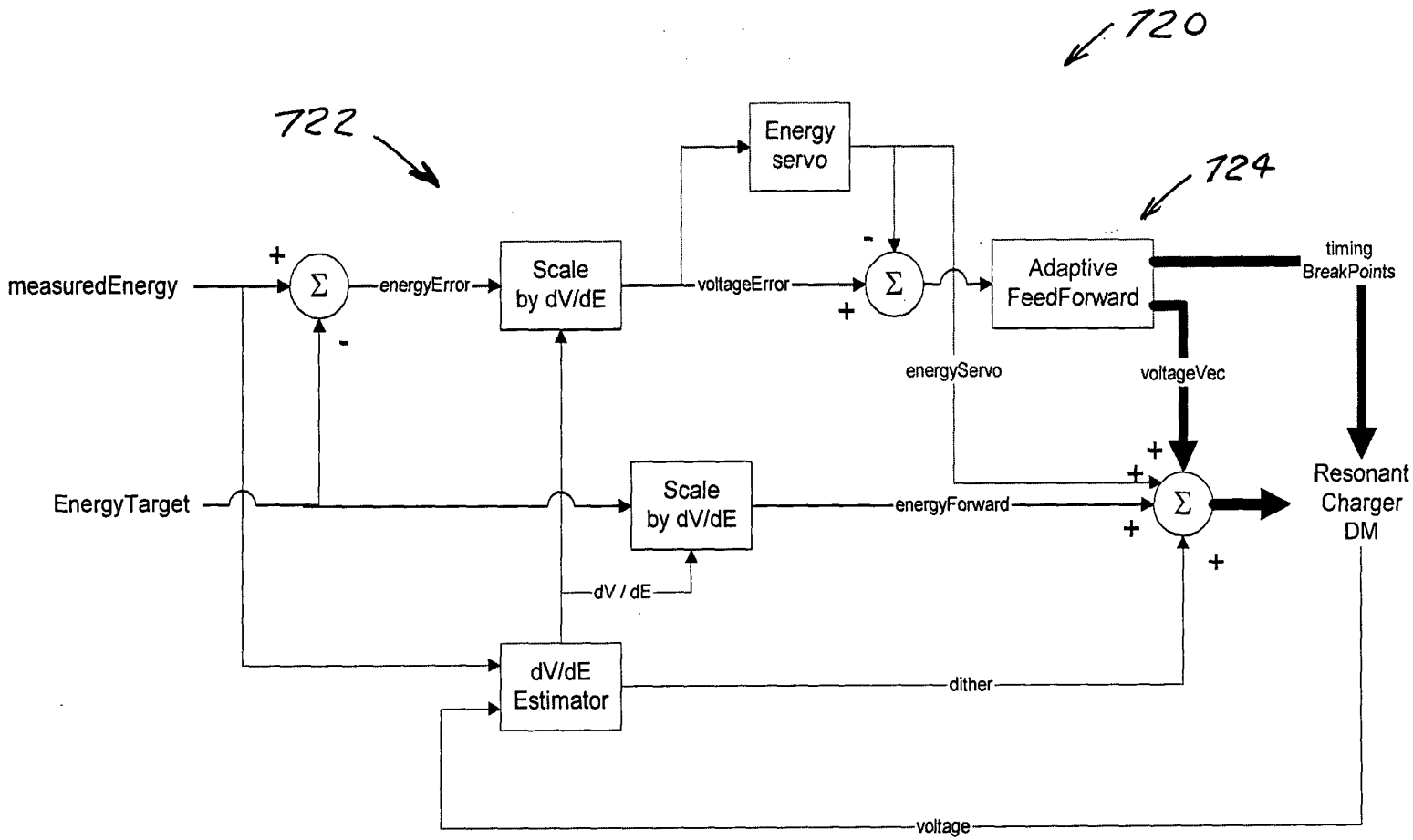
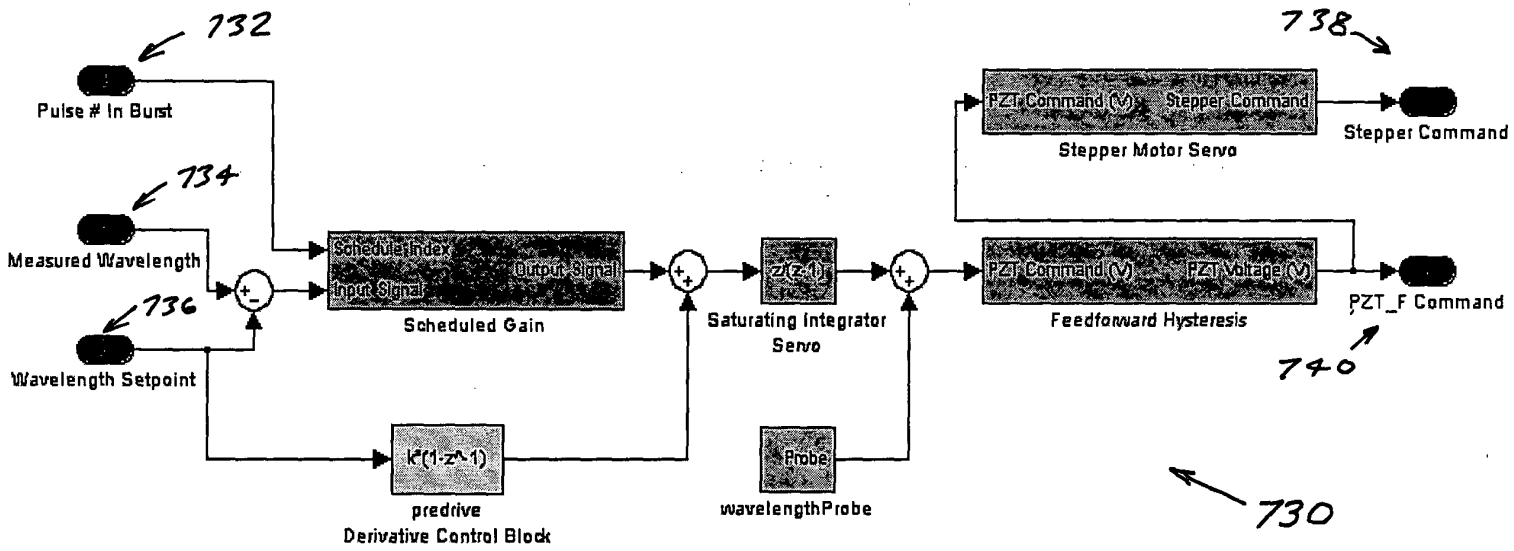


FIG. 11B

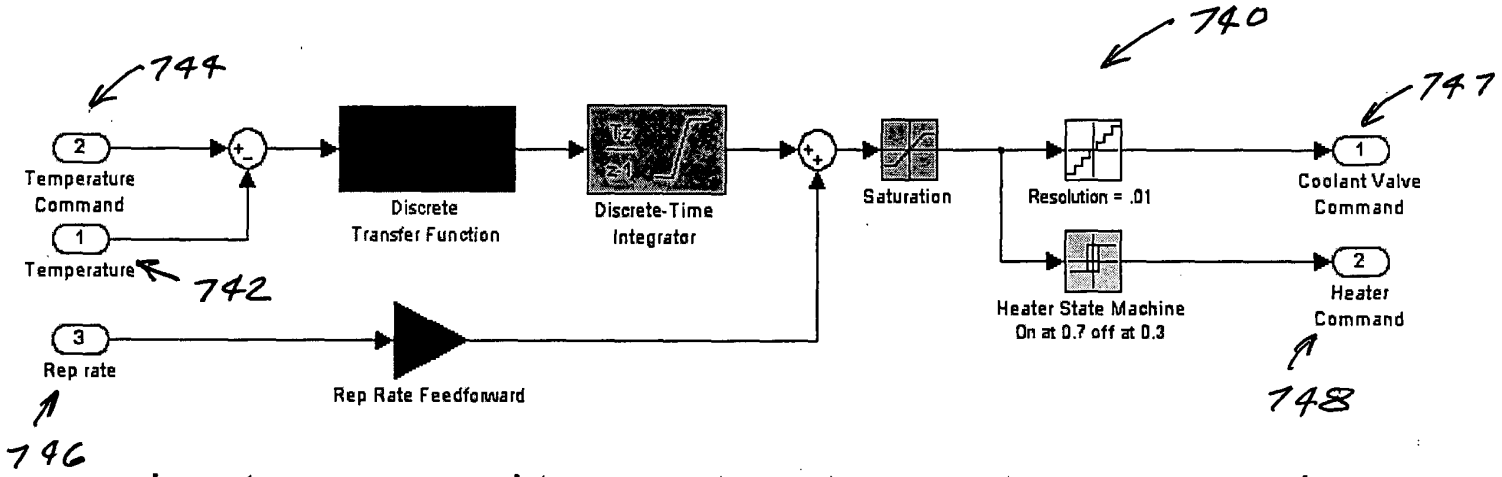
Wavelength Control Algorithm



- Inputs: measured wavelength, target wavelength, pulse number in burst
- Outputs: stepper command and PZT voltage command
- Measured wavelength received from LAM, actuator commands sent to LNCM

FIG. 12

Gas Temperature Control Algorithm



- Inputs: measured temperature, temperature command, average repetition rate
- Outputs: coolant value command, heater command
- Two independent, identical loops for the two chambers
- Measured temperature is received from CAN I/O clusters, valve and heater commands are sent to CAN I/O clusters
- The loop executes at 10Hz

FIG. 13

750

F2 Inject Algorithm: State Diagram

- The algorithm is based on the idea of tracking the Burst Average Voltage (BAV) and monitoring the rise in this voltage due to F2 depletion
- Change in Operating Point (i.e., a new rep rate, energy target, or duty cycle) requires adjusting the reference voltage to which the voltage rise is compared

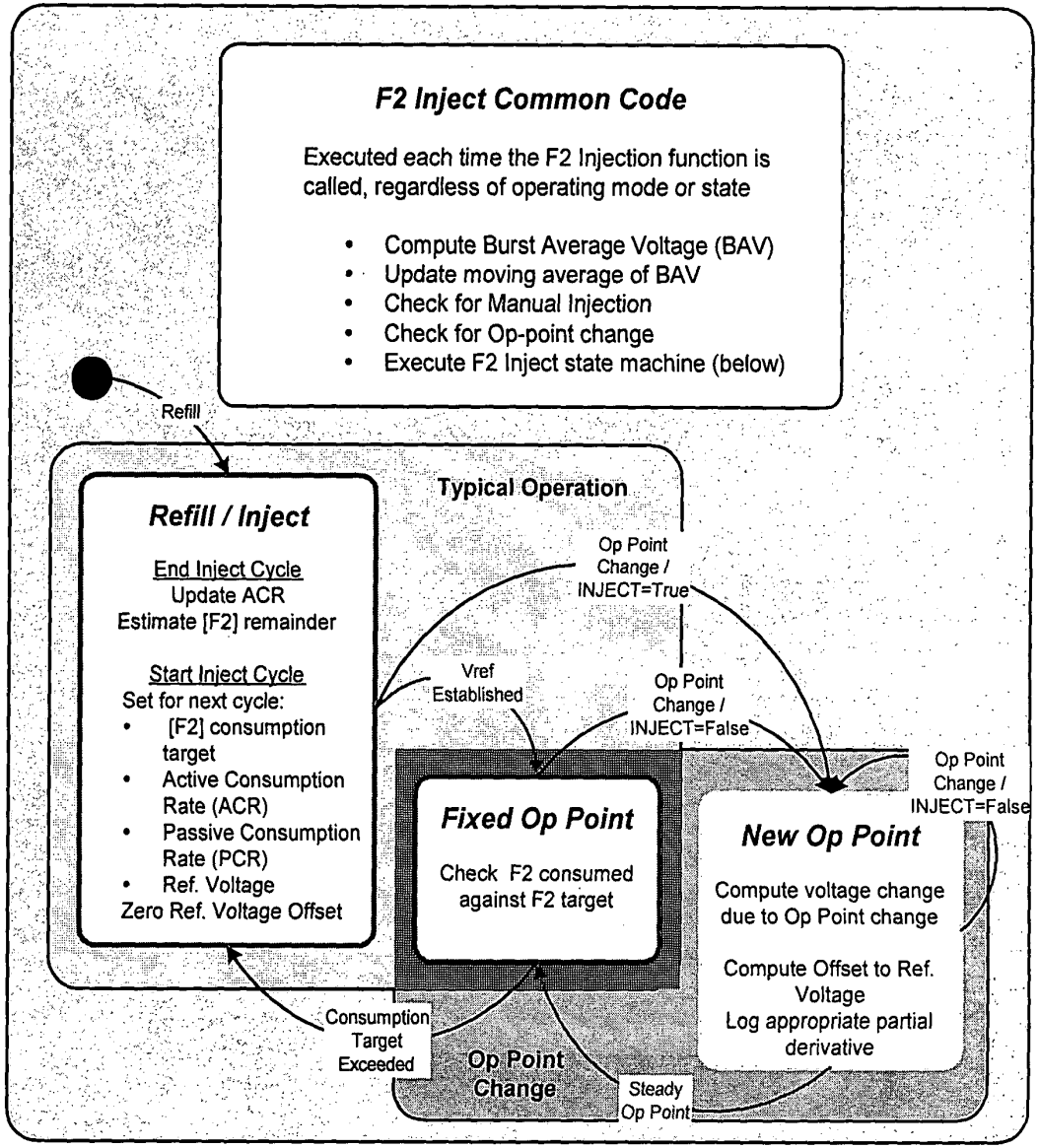


FIG. 14